SOIL AND WATER USE IN THE SOVIET UNION

REPORT OF A TECHNICAL STUDY GROUP

Soil Conservation Service

UNITED STATES DEPARTMENT OF AGRICULTURE

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FOREWORD

An Agreement, concluded on January 27, 1958, between the Governments of the United States of America and the Union of Soviet Socialist Republics, provides for exchanges in the cultural, technical, and educational fields during the years 1958 and 1959. This Agreement has been regarded as a significant first step in the improvement of mutual understanding between the peoples of the two countries.

Agriculture, which plays an important role in the national economics of the two countries, was specifically included in the Agreement as a field for exchange of specialists. The U. S. Department of Agriculture accordingly sent to the Soviet Union in 1958 six technical study groups of specialists in the following subjects: Agricultural economics; agricultural crops, soil, and water use; veterinary science; mechanization of agriculture; cotton growing and plant physiology. In 1959 it is planned to send three additional study groups in the following fields: Forestry, lumbering, and millwork; sheep raising; biological control of agricultural pests.

The Soviet Union in turn sent to the United States in 1958 six delegations of specialists in the following subjects: Farm mechanization; hydroengineering (irrigation) and reclamation; animal husbandry; cotton growing; agricultural construction and electrification; veterinary science. In 1959 three additional Soviet teams are expected in the following fields: Mixed feeds; forestry, lumbering, and millwork; horticulture.

Each U. S. exchange study group, on completion of its assignment, prepared a report for publication. Soil and Water Use in the Soviet Union represents the report of the Soil and Water Use exchange group and was prepared by: Charles E. Kellogg, Chairman, Soil Conservation Service; William H. Allaway, William W. Donnan, and Lewis B. Nelson, Agricultural Research Service; and Joseph J. Bulik, Foreign Agricultural Service, U. S. Department of Agriculture; and Marlin G. Cline, Cornell University; and D. Wynne Thorne, Utah State University.

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Washington, D. C.

June 1959

SOIL AND WATER USE IN THE SOVIET UNION

. . . Report of a Technical Study Group

INTRODUCTION

On the basis of an exchange agreement between the Governments of the United States and the Soviet Union of January 27, 1958, the United States Department of Agriculture chose six technical study groups to visit the USSR in 1958. The Technical Study Group on Soil and Water Use was one of these six. The purposes of this study group were to become acquainted with (a) work done in the USSR in achieving a balance between basic and applied research within the field of soil and water management, (b) work done at the field experimental stations and laboratories, (c) the use of soil maps in planning for and in assistance to collective and state farms in their soil and water management, and (d) the methods by which collective and state farms were given information about improved techniques of soil and water management. It was essential that the study group have access throughout the trip to field experimental stations, collective farms, and state farms involved in a practical way and to a significant degree with problems of soil and water management.

Members of the Technical Study Group

As chairman of the technical study group on Soil and Water Use, the United States Department of Agriculture chose Charles E. Kellogg, Assistant Administrator for Soil Survey, Soil Conservation Service, who had previously visited the USSR in June 1945 during the 220th anniversary of the Academy of Sciences of the USSR. He was familiar with soils research conducted in the USSR and had maintained a professional relationship with several Soviet soil scientists over the years.

Other members of the technical study group were as follows:

William H. Allaway, Assistant Director, Division of Soil and Water Conservation Research, Agricultural Research Service, United States Department of Agriculture.

Joseph J. Bulik, Special Assistant in the Foreign Agricultural Service, United States Department of Agriculture. He had served in the USSR from 1944 to 1948 as Agricultural Attache.

Marlin G. Cline, Professor of Soil Science, Cornell University, Ithaca, N. Y.

William W. Donnan, Principal Agricultural Engineer, Division of Soil and Water Conservation Research, Agricultural Research Service, United States Department of Agriculture, Pomona, Calif.

Lewis B. Nelson, Chief, Eastern Soil and Water Management Research Branch, Division of Soil and Water Conservation Research, Agricultural Research Service, United States Department of Agriculture.

D. Wynne Thorne, Director, Utah Agricultural Experiment Station, Utah State University, Logan, Utah.

Itinerary of the Study Group

Prior to departure from the United States, a suggested itinerary for the study group had been submitted to the Ministry of Agriculture of the USSR by the United States Departments of Agriculture and State. In conference at Moscow this itinerary was slightly reworked with officials of the Ministry of Agriculture.

The itinerary was selected with the view in mind of observing soil and water management in the important agricultural areas of the USSR, including those areas with problems of drainage, of irrigation, of erosion hazard, of soil-blowing hazard, of fertility maintenance, and of new-land development.

The technical study group was accompanied throughout the trip within the USSR by three Soviet citizens. They were: Vasilii M. Melnikov, Vice Chief of the Division of Water Economy of the Ministry of Agriculture of the USSR, who was in charge of the tour and handled all necessary arrangements; Edward V. Baranov, an interpreter supplied by the Interpreter's Department

Itinerary of the technical study group on Soil and Water Use

of the USSR Agricultural Exhibition in Moscow; and Pavel S. Shelest, special correspondent of the Soviet agricultural newspaper Selskoe Khozaistvo.

Local offícals and scientists of the republics, oblasts, and institutes were very helpful as were managers and staff on the state and collective farms.

The itinerary was as follows:

July 16 - Departure from the United States.
July 18 - Arrival in Moscow, USSR.
July 19 - Meeting with USSR Ministry of Agriculture officials.
July 20 - Visit to All-Union Agricultural Exhibition, Moscow.
July 21 - Lenin Academy of Agricultural Sciences, the Dokuchaiev Institute of Soil Science.
July 22 - Timiryazev Agricultural Academy.
- Moscow State University.
July 23 - The All-Union Institute of Fertilizers and Agro-Chemistry.
- Departure for Minsk, White Russian (Belorussian) SSR
July 24 - Meeting with Minister of Agriculture, White Russian SSR.
- The Belorussian Scientific Research Institute of Amelioration and Water Utilization, Minsk.
- The Minsk Experimental Station.
July 25 - The Volma Lands Reclamation Project.
- Komintern Collective Farm, Minsk Oblast.
July 26 - New Life Collective Farm, Minsk Oblast.
- Departure for Kiev, Ukrainian SSR.
July 27 - October Collective Farm, Kiev Oblast.
- The Ukrainian Agricultural and Industrial Exhibition, Kiev.
July 28 - Visit with the Minister of Agriculture, Ukrainian SSR.
- Departure for Poltava by automobiles.
- Stalin Collective Farm, Poltava Oblast.
July 29 - Visit with Chief of the Poltava Agricultural Administration.
- The Poltava Provincial Agricultural Experimental Station.
- Departure for Dnepropetrovsk by automobiles.
July 30 - Orzdhonikidze Collective Farm, Dnepropetrovsk Oblast.
- Dneprovski State Farm, Zaporozhe Oblast.
July 31 - All-Union Scientific Research Institute on Corn.
- Departure for Rostov.
Aug. 1 - Visit with agricultural officials of Rostov Oblast and with Southern State Institute for Designing Water Economy.
- Koisug State Farm, Rostov Oblast.
- Red Orchard State Farm, Rostov Oblast.
- Lenin Collective Farm, Rostov Oblast.
Aug. 2 - Departure for Krasnodar.
Aug. 2 - Economy of Krasnodar Krai and other agricultural officials.
- The Kuban Rice Experimental Station.
Aug. 3 - Krasnoarneisk State Farm, Krasnodar Krai.
- Michurin Collective Farm, Krasnodar Krai.
Aug. 4 - Departure for Stalingrad.
- Visit with agricultural officials, Stalingrad Oblast.
- Brief visits to afforestation areas.
Aug. 5 - Stalingrad Agricultural Institute, Stalingrad Oblast.
- All-Union Scientific Research Institute of Agro-Forest Amelioration, Stalingrad Oblast.
- 40th Anniversary of the October Revolution Collective Farm, Stalingrad Oblast.
Aug. 6 - Stalingrad to Tashkent via Moscow.
Aug. 7 - Visit at Ministry of Agriculture, Uzbek SSR.
- Middle Asia State Project.
- Institute for Water Economy and Cotton, Tashkent, Uzbek SSR.
Aug. 8 - Akhun Babaev Collective Farm, Tashkent Oblast, Uzbek SSR.
- Middle Asian Institute of Mechanization and Electrification of Irrigated Agriculture, Yangi-Yul, Uzbek SSR.
Aug. 9 - The Akkavak Central Agro-Technical Station, Tashkent Oblast, Uzbek SSR.
- The Experimental Station of the Middle Asian Scientific Research Institute of Plant Breeding of the USSR.
Aug. 10 - Departure for Andizhan, Uzbek SSR.
- Visit to the Bolshoi Fergana Canal.
Aug. 11 - Savay State Farm, Andizhan Oblast, Uzbek SSR.
Aug. 12 - Sverdlov Collective Farm, Andizhan Oblast, Uzbek SSR.
- Andizhan to Tashkent.
Aug. 13 - Meeting with agricultural officials of Uzbek SSR.
- Departure for Akmolinsk, Kazakh SSR.
Aug. 14 - 18th Anniversary of Kazakh Republic Collective Farm, Akmolinsk Oblast, Kazakh SSR.
- Kazakh Scientific Research Institute on Grain-Crop Growing, Shortandy, Akmolinsk Oblast, Kazakh SSR.
Aug. 15 - Shortandsinski State Farm, Akmolinsk Oblast, Kazakh SSR.
Aug. 16 - Departure for Moscow.
Aug. 19 - Visit with Vice Minister of Agriculture of the USSR, Gennadi A. Barkov.
Aug. 20 - Departure for the United States.

Comparison in general terms of agriculture as a whole in the Soviet Union with that of the United States or of any other country is essentially impossible. Nor can one easily generalize on the narrower topic of soil and water use. The various phases are developed unevenly in relation to developments in the United States and elsewhere.

First of all, trends in development are probably more important than the actual status of development in 1958 or any other recent year. The study group received the definite impression that the trends of good husbandry, farm diversification, efficient use of modern technology, crop yields, and total production were definitely upward. Yet wide variations were seen among the several aspects of research, education, and practice. The government has placed somewhat different priorities on facilities and set somewhat different goals than agriculturists from other countries might have suggested.

Secondly, one must recall that most of the farm people of the Soviet Union have had a different cultural background than most of the farm people of Western Europe and the United States. Under strong Roman influence for a great many years, Western Europeans inherited from the Romans the idea of independent responsible farm managers. Thus, the self-reliant family farm came with the Romans into Western Europe and from thence to what is now the United States. On the other hand, few of the peoples of the Soviet Union fell under this Roman influence. The land was held largely by the Emperor or by individuals in the aristocracy. Even after the serfs were freed just after the middle of the last century, it was a long time before modern farming was undertaken or even possible except for relatively few estates and communities.

Thirdly, the Russian Government under the Czars had serious political difficulties from before 1900 through World War I, which culminated in a revolution and a bitter civil war. Thus modern farming in the terms we understand it was not widely attempted until the late twenties. Despite the many difficulties in a situation where everything needed doing at once, some real progress was apparently made. Then came the terrible destruction of both cities and farms in a large part of the most productive areas in the country during World War II. Many, many farms lost nearly all their livestock and buildings. Immediately after the war great difficulties of transport and reorganization of industry had to be overcome to rebuild the farms and the factories supplying farmers with essential materials for modern husbandry.

Fourthly, it is difficult to assess the long-time effects of recent consolidations of collective and state farms. Now there are said to be slightly less than 90,000 farm units in the whole of the Soviet Union. This does not, of course, count the small plots on each collective and state farm of 1/4 of an acre to 3 acres allotted to each family for its own use. This great consolidation means, of course, an enormous concentration of management skills and responsibilities as compared to most other agricultural countries. In some ways this consolidation facilitates government planning and control. Such controls permit the prompt and widespread establishment of new practices, the poor ones as well as the good ones.

Finally, one needs to recall that the Soviet Union is made up of many lands and peoples grouped into 15 semiautonomous republics. A total of 82 languages are spoken in the country. The Russian Republic is the largest and probably plays a dominant role in the political life of the country; yet the soils, climates, vegetation, people, ideas, customs, programs, and policies vary substantially from place to place.

Itinerary

The route of the technical study group is shown on the outline map. After planning the itinerary in the Ministry of Agriculture several of the important academies and institutes were visited in Moscow.

The highest authority on soils in the Soviet Union is the Dokuchaiev Institute of Soil Science, which is a constituent part of the Academy of Sciences of the USSR. This main Academy, with very high scientific standards, was organized nearly 250 years ago. Emphasis in the Academy and its constituent parts is on basic science and scientific principles, although their research is carried part-way toward application. In agriculture, however, more of the responsibility for application is with the academies of agricultural science and other research institutes under the Ministry of Agriculture of the USSR, ministries of agriculture of the individual republics, and the academies of agricultural science.

Much of the direct technical assistance given to farms is furnished by the ministries of agriculture of the republics, the agricultural administrations of the oblasts, and the agricultural administrations in the raions.

Except for visits near Minsk, White Russia (Belorussia), primarily to see the research on drainage and the field methods for the reclamation of organic soils, the field studies of the study group were made in relatively treeless areas in the Ukraine; in Russia near Stalingrad, Rostov, and Krasnodar; in Uzbekistan; and in the northern part of Kazakhstan.

The study group visited several of these various kinds of institutes along the route and both state and collective farms. The visits to these farms were made in the company of scientists and engineers from local institutes and agricultural administrative officers. Throughout the visit time was at a premium. During some visits we were able to get a rather complete statement about enterprises and practices on the farms and a good look at some of the field crops and field operations. In others either darkness or the pressure of plane schedules left us time for only incomplete examinations.

We were impressed with the sincerity of our Soviet hosts and with their efforts to give us as complete information as possible in the time available. Yet it was clear that they were trying hard to make a good impression, somewhat as Americans do when acting as hosts in our country. On some farms, the local managers even had a bit of prompting from higher officials and technicians. In the institutes we found considerable difference of opinion, even about a few technical ideas clearly promoted by Government policy.

Nearly all of this information came through interpretation, and in some parts of the country double interpretation, from the local language to Russian and then to English. So there were opportunities for errors and misunderstanding. Then too, each farm we visited had a plan toward which the leaders were working. It was not always easy to differentiate between statements about the plan and statements about actual current practices. In some places there may have been some confusion between plan and practice, and with the goals of the new 7-year plan beginning in 1959.

Soil Classification and Soil Maps

Russian soil scientists were early leaders in the basic research into the nature, genesis, and geography of soils. From about 1870 to 1930, a vigorous group of scientists were led, in turn, by V. Dokuchaiev, N. Sibirtsev, and K. D. Glinka. Many other distinguished names could be added to the list. The results of these researches, and the soil classification they made possible, became widely known through the publication of Professor Glinka's textbook in German in 1914, and its translation into English by C. F. Marbut in the early twenties. Soil research was enormously stimulated throughout the world. Thus many of the terms of soil science in current use throughout the world are from the Russian language.

Although relatively an advanced system as finally developed by Professor Glinka, the study group received the impression that it has now become accepted as highly classical and almost beyond criticism. Researches are being made to perfect it, to explain it, and to extend it; but it does not appear that the system is under the critical review and reworking necessary in order to bring into it the vast new knowledge about soils that has accumulated in the last 30 years.

This system of soil classification was widely used and understood throughout all the areas visited, not only by soil scientists but also by other agricultural scientists, by farm managers, and by the agronomists and other technicians who work with agricultural planning. It serves as the foundation for farm planning, for essentially all soil research, and for teaching soils in the institutes and the universities.

According to the principles promulgated by the Dokuchaiev Institute through publication of small-scale soil maps made by expeditionary teams of scientists and other authoritative guides, soil mapping of state and collective farms is going forward rapidly. Priority has been given to farms being developed through drainage and irrigation, to those in the new-land area, and to those needing drastic reorganization. Most oblasts visited reported that soil-mapping work is nearly finished or reported completion dates some 2 to 5 years hence.

Soil maps of farms range in scale from about 1:5,000 to 1:20,000, depending upon the intensity of use and the complexity of the patterns of different kinds of soil. Some

of those made before World War II were on scales of 1:25,000 or 1:50,000. Several copies of these are made for use in farm planning but they are not published. We saw several of these soil maps but had no opportunity to check the boundaries and the classification through detailed field examination. Many of them looked to be rather good, especially those made since 1945.

The classification units on these maps appear to be more broadly defined than those on detailed soil maps now being made in the United States. The basic units in the soil nomenclature are mainly the great soil groups (such as Chernozem, Sierozem, Chestnut, and Solonetz) and subgroups of these. The mapping units are phases of the groups or subgroups as needed to differentiate local kinds of soil according to differences in texture, slope, thickness, and the like. The soil maps examined also had fewer boundaries--less cartographic detail--than those now being made in the United States for farm planning. Apparently the user of soil maps in the Soviet Union is expected to recognize himself inclusions of small areas of one kind of soil within the area of another kind shown on the map that would be mapped out for him by the American soil scientist.

It is probable that these less detailed soil maps are suitable for the needs in the Soviet Union whereas they would not be suitable for comparable biological zones in the United States for several reasons: (1) On the staff of each farm we visited there were from 1 to 15 agronomists, trained in soil classification and the use of soil maps; (2) a great many of the farms lie in relatively uniform areas of nearly level to undulating soils from deep loess that do not have many strongly contrasting local differences; and (3) the lack of well-designed field experiments with replicated and randomized plots means a lack of supporting data to interpret differences among similar kinds of soil that would have different recommendations for treatment in the United States and several other countries. Yet the broad use potentialities are apparently indicated clearly by the soil maps. At least the study group saw few examples of soil unsuited to crops being used for crops.

Thus the soil maps appear to be adequate for extending the principal recommendations growing out of research and experience in the Soviet Union. On many farms the basic soil maps are supplemented with others indicating available phosphorus, acidity, humus content, and the like based on the example of soil samples in the laboratory. Many phases of irrigation and drainage design and practices appear to be related to the kinds of soil shown on these maps. Information about local crop rotations and many other phases of farming were spelled out by kinds of soil as shown on the maps.

Thus under current conditions at this stage of agricultural development in the Soviet Union, the system of soil classification and the results of soil mapping are widely used in farm planning, seemingly with much success. On the examples seen, it was clear that soil maps made since World War II were considerably more detailed and appeared to be more accurately drawn than those made before World War II. In some places considerable emphasis was given to detailed interpretations, especially on the newer soil maps, in terms of both soil properties and the qualities of soil for different uses. As time goes on one may expect some breaks in the classical tradition and perhaps another wave of new development in soil classification within the Soviet Union.

In the Soviet Union there are large areas of good soil, including much yet to be developed (a) by ordinary breaking and plowing, especially in parts of Siberia and the northern part of Kazakhstan; (b) by irrigation, or by combined irrigation, drainage, and salinity control, in the southern parts of the country, including the lower valleys of the Volga, the Dnepr, the Don, the Kuban, the Syr-Darya, and many other streams; and (c) by drainage, especially in White Russia. (Some development of good soil had been delayed because of lack of transport.)

Many of the good soils were developed naturally under grass, or a combination of grass and forest, on undulating deposits of loess. Much of the agricultural land has a moderate to high climatic risk: Some years are too cool and wet from an extension of the Baltic climate, and some summers are dry from an extension of the Mediterranean climate from the southeast or of the desertic climate from Middle Asia.

Laboratory Research in Soil Science

Generally, the Soviet soil laboratories visited by the study group have instruments and equipment similar to those in American laboratories. The laboratories of the Department of Pedology (Soil Science) of the University of Moscow were especially well

equipped. Yet most of them had some equipment considerably less modern than that found in most American soil laboratories. This was especially true in sections where routine soil and plant analyses were being made. The number of subprofessional assistants in Soviet laboratories seemed to be considerably higher than in most of those in the United States. The apparent availability of such technical assistants, probably on modest salaries, has undoubtedly had the effect of reducing the urgency for more rapid analytical procedures and instruments.

Many of the research laboratories visited were using radioactive isotopes with instruments comparable to those used in the United States and Western Europe. The researchers seemed to be familiar with American methods and literature.

On the whole the study group found that relatively little use was being made of the most advanced instrumentation for the study of soil moisture, nor did many of the scientists with whom we talked seem to be using the newer energy concepts in studying the moisture in soils and its relation to plants. Yet there is a great need for studies along this line, perhaps more especially on irrigated soils but also in many soils where moisture and moisture conservation were highly critical factors in crop production.

In greenhouse and field experiments we noted a lack of randomization of either pots or plots as required by the most modern experimental design.

Little of the work seen by the study group in Soviet soil laboratories would suggest the use of concepts that are not known at least in the better laboratories of the United States. It would seem that some of the work underway at the University of Moscow on plant growth toxins and stimulants of microbial origin in soil deserve close attention by American soil scientists. It was noted that several of the research leaders were emphasizing the belief that research in soil microbiology needed greater emphasis in the Soviet Union. If their views are correct, perhaps it needs greater emphasis in the United States also.

In the soil research laboratories, as elsewhere, the study group was impressed that Soviet research scientists are better informed on the results of American research than are their American counterparts with Soviet research. Books, monographs, and journals from the United States were in evidence. Some of these had been translated in full, and workers had access to abstracts in the Russian language of most foreign scientific literature. It will doubtless become increasingly urgent for soil scientists in the United States to become more currently familiar with Soviet soil research as their efforts continue to expand.

Crop-Rotation Systems

Rather long rotations of several crops are common in the Soviet Union. Many factors are involved in these rotations. Partly the poor transport in the country requires regional diversification including some crops for local use that are not ideally suited to the combinations of soil and climate. Partly the rotations are influenced by the serious weed problem in the country. Perhaps weeds are not more serious, potentially, than in the United States, but the Soviets have not yet widely applied herbicides and need to depend on tillage and proper adjustments of crop rotations more than do modern farms in the United States. On the other hand, soil erosion is a less serious problem except for serious gullying in a few places. Then too, the papers of Professor V. R. Williams have had a great influence.[1] Finally, the rather rigid scheme of national planning with production quotas for each state and collective farm has its influence, perhaps partly good and partly not, in determining the acreages of industrial, food, and fodder crops that must be provided for in the farming systems.

It seemed to the study group that many of these long rotations in the plans were highly complicated and by no means always followed in practice. Some of them involved planning ahead on a particular field for as much as 20 years. In the meantime there are dry years and wet years and shifts in government planning. Then too, managers of the farms are anxious to maximize their production because of the bonuses received when farms exceed their quotas.

Good rotation pastures, including perennial grass-legume mixtures, are not so common in the Soviet Union as in the United States and Western Europe. We saw cattle on pasture, especially on aftermath following the harvest of cereals, and on virgin grassland in the new-land area; but far

[1] Williams, V. R. Principles of Agriculture. Trans. by Jacks, G. V. 156 pp. illus. Chemical Pub. Co. New York. 1952.

greater dependence than in the United States is placed on soiling crops that are cut green and hauled to the feeding areas. Generally the use of grass silage, except in mixtures with corn and other fodder crops, is not so common as in Western Europe and parts of the United States.

According to the information we received the legume-grass mixtures are given emphasis on the acid podzolic soils and on the peat soils--but relatively more emphasis on their effects in maintaining soil fertility and productivity than on their use for pasture. Most of our observations were made on the soils of the more southern and central parts of the country. These soils were naturally treeless or supported mixtures of trees and grass-steppe and forest-steppe. Generally, it did not appear to us that enough perennial-legume mixtures and manures were being used to maintain the supplies of organic matter in these soils, except on the farms using irrigation on the Sierozems. Yet we were generally impressed with the relatively good structure and permeability of the long-cropped soils of the Chernozem group.

The study group gained the impression that the recommendations for crop rotations given to the state and collective farms were based mainly on theoretical considerations, including the speculations of Professor V.R. Williams and others, and local experience rather than on well-designed and replicated field experiments. Most of the experiments seen dealing with crop rotations were set up to measure yields and the longtime effects on soil productivity rather than to make reasonably precise comparisons among alternative systems. Most of the trials seen were set up in relatively large plots, or even fields of more than 200 acres, with few or no replications.

Yet it must be said that essentially all farms visited had a definite plan of crop rotation and that on the whole these were reasonable. Certainly many of them could be improved and likely such improvement will come with better techniques for field experimentation and with less pressure on farms for unadapted crops. An example of this latter pressure is the recent emphasis on corn, which has resulted in corn being grown in dry areas where grain sorghum would be more appropriate and in corn planting in both dry and moist cool areas where other fodder crops would be more productive. Corn is a good crop for many areas, but it is being widely seeded in places where the climate is not favorable. Less extreme emphasis is also given to cotton, sugarbeets, and other industrial crops.

Bacterial Fertilizers

Besides legume inoculants of Rhizobium, the Soviets commonly treat seeds with two other cultures, (1) azotogen or Azotobacter to inoculate the soil with the nonsymbiotic nitrogen-fixing bacteria, and (2) phosphobacterin for encouraging rapid decomposition of phosphorus-containing soil organic matter. On many farms these cultures are used to treat seeds of corn, small grains, flax, cotton, and vegetables. In the new-land area, the phosphobacterin is on wheat to increase the amount of "active" phosphorus in these organic-rich Chernozem and Chestnut soils. Elsewhere that the cultures were used it was claimed that they were supplements to and not replacements of manures and fertilizers. Although another type of silicate-decomposing bacteria, intended to release soil potassium in available form, had been reported in the Soviet literature, the study group did not find it in use.

The study group found a considerable difference of opinion among experienced scientists and practical agriculturists about the value of both the azotogen and the phosphobacterin. The field testing that we saw was carried out on large fields without adequate experimental design and controls to measure the relatively small differences that could be expected, if indeed significant effects are produced by these cultures. Apparently the leading agricultural administrators are convinced of their value so that they are manufactured and used in large quantities. Perhaps many farm managers would not use them if the matter were left entirely to their own judgment.

The Ministry of Agriculture of the USSR made available to the study group a quantity of the phosphobacterin, and a small quantity of the azotogen has been promised. It is planned to have rigorous tests made of these in the field by soil scientists of the Soil and Water Conservation Research Branch of the Agricultural Research Service. It is hoped that these experiments can lead to definite conclusions about the value of such cultures on representative soils and crops in the United States.

Mineral Fertilizers and Manure

The manufacture and use of mineral fertilizers is increasing in the Soviet Union. New plants are under construction and

others are in the plans. The study group saw examples of nutrient deficiency on crops, but the agricultural specialists with whom we visited are fully aware of the needs for more fertilizer.

Research and testing work on fertilizers is carried out at many of the institutes we visited, including several devoted to work on individual crops, such as cotton, corn, and rice. Much of the coordination of this work appears to be handled by the All-Union Institute of Fertilizers and Agro-Chemistry under the Lenin Academy of Agricultural Sciences. The Institute makes recommendations directly to the Ministry of Agriculture of the USSR.

In the research work emphasis is given to phosphorus, potassium, and nitrogen. Finely ground rock phosphate is recommended and used on the acid podzolic soils and ordinary superphosphate on the chernozemic soils. Research is underway on other forms of phosphorus and in places there is considerable field use of anhydrous ammonia. The principal nitrogen fertilizers are ammonium sulphate and ammonium nitrate. Lesser amounts of potassium are being used and there is some important use of manganese and copper.

On the whole the physical quality of most of the mineral fertilizers seen is rather poor by American standards. The individual fertilizers are received on the farms as unmixed goods to be applied directly or mixed on the farm prior to application.

Generally speaking, the farms have reasonably good technical services to help guide the use of fertilizers and lime. These include basic soil maps followed by soil testing and frequently by the preparation of special maps showing soil acidity and available nutrients for the individual farms.

In the new-land area mineral fertilizers are not used. The soils have only recently come under the plow and are relatively high in fertility. In this area the manure is not used on the soil but is used for making fuel bricks. In some other places where fuel is scarce manure bricks are used.

Fertilizer application methods generally lack precision. Yet we saw some machines for sidedressing nitrogen and phosphate fertilizers and good applicators for anhydrous ammonia. Apparently airplanes are used extensively for broadcasting mineral fertilizers. Manure is handled crudely and with high labor costs. Although many farms have carriers on tracks for removing the manure from the barns, most of it is hauled to the fields in little horse-drawn wagons, dropped into piles, and later spread by hand.

For studying soil fertility and the effects of fertilizers we saw no good experimental plots properly randomized and replicated in the modern manner. With this lack of good experimental data some inadequately tested theories that appeared highly questionable to the study group are widely adopted. An example would include mixtures of dried manure and superphosphate applied as late sidedressings on crops like cotton. Although a great deal is written about the use of fertilizers for the farm managers and agronomists, it would seem that decisions by the government had more to do with the fertilizer practices on Soviet farms than does extension education as we conceive it in the United States and Western Europe. These actions by the government lead to rapid adoption of practices but, of course, magnify any errors in judgment that might have been made.

So far as the study group could interpret its observations, skill in the use of fertilizers is increasing and better practices will doubtless be developed and adopted. Yet at the present time none of the practices observed in the Soviet Union are superior to those used by commercial farmers in Western Europe and in the United States. Many are inferior.

Drainage

The very large research and reclamation program in White Russia for bringing more than 3,500,000 acres of excellent peat soils into use for cultivation was impressive. The major works are constructed by the government and the costs of works on the farms are shared by the farmers and the government. The drainage work, land preparation, and farm planning are backed up by a well-financed and well-directed research institute of the White Russian Republic.

The study group observed many newly built machines under test. Most of these appeared to work well. Although built in the Soviet Union they were partly designed after Western European and American models.

Considerable research is underway on the spacing of both open and closed drains in relation to water tables and crop yields. Since the main streams are carrying snowmelt in the spring, the problem of coordinating drainage of the peat soil with the fluctuations of the flow in each major river system has been carefully studied as a

basis for workable plans of drainage in relation to planting seasons.

Although our Soviet hosts indicated satisfactory results, to the study group the drains seemed somewhat too widely spaced and the water table drawn down somewhat too far. But of course this same thing is true of some American drainage schemes on peat soils.

In the irrigated areas, and especially in the new reclamation of the Hungry Steppe near Tashkent, drains were very far apart. Soils are somewhat salty and require rather large amounts of water to move the salts down. The study group would expect that considerable further drainage, and especially tile drains, would be required to prevent the gradual development of a salinity problem. Yet the good crops that we observed did not appear to be suffering significantly from salt damage.

Irrigation

The study group was impressed with the large works for water storage, flood control, and irrigation that have been recently installed, and with the large plans for expanding irrigation during the next few years. The major works are financed by the government and costs of farm development are shared by the government and the farms somewhat differently in different areas, partly according to the present wealth of the collective farms. In the Hungry Steppe essentially all of the costs are borne by the government since many farms are being established there. Large increases in cotton, rice, fruits, vegetables, and several other crops are expected to result.

Although the Soviets have apparently made considerable progress in both research and practice, additional and more precise research is needed, especially on soil salinity and on the interactions among water application, fertilizers, and plant population on different soils. Here, too, they are handicapped by inadequate design for controlled experiments that will give reasonably precise comparisons among alternatives.

Good progress has been made in field layouts and in farm reorganization for irrigation. The yields of most irrigated crops seen by the study group were good. But the handling of the water on farms is not well controlled and current methods require a large amount of farm labor. As in some other phases of soil management, it appeared to the study group that the farm irrigation practices were closer to the limits of available technical information than in the United States.

Soil Management for Rice Production

The study group was impressed with the research and promotion work of the Kuban Rice Station of the Ministry of Agriculture of the Russian Republic at Krasnodar. The work includes plant breeding for early varieties that can be grown in warm but short seasons, soil selection, irrigation methods, fertilization, and the other cultural practices in proper combinations.

The development has been concentrated in the lower valley of the Kuban River, especially following the construction of large floodwater reservoirs, canals, and dikes. Rice growing began in 1932. Besides the work in Krasnodar and on the experimental fields in the Kuban Delta, "checking experiments" are carried out by expeditionary teams of specialists in the lower Don and Volga valleys and in the Terek Delta.

The experimental work on fertilizer use and for comparing alternative rotations is not well replicated or randomized. Yet useful results have been obtained for recommendations to farms. Rice yields at the experimental farm ran from 3 to 5 tons per hectare. Those on two farms visited by the study group were about 2-1/2 to 3-1/2 tons per hectare. In our view, overemphasis was given to late applications of phosphatic fertilizer. Weed problems can be serious, and costs could doubtless be reduced greatly with proper herbicides. Still, the results are promising for a new enterprise of rice growing so far north.

Soil Erosion and Soil Blowing

Generally, soil erosion is less serious in the Soviet Union than in the United States, partly because a higher percentage of the land used for crops is level to undulating, partly because of the pervious nature of the majority of soils, and partly because a smaller part of the rain comes in showers of high intensity. In many places, however, the perennial streams have entrenched themselves deeply into the loessial plains. Natural ravines lead back from the rivers into these plains and along their sides one sees considerable destructive gullying. This was especially noticeable along the lower Volga and Don Rivers. Other examples could be seen along streams in the Ural Mountains and elsewhere.

The Soviets do well with vegetative practices for erosion control, such as tree planting and guarded grass, but they make rather poor use of terraces, diversion terraces with chutes, and other farm structures for gully control. They know how to make such kinds of structures; we saw them along railways and near some cities. Except for large dams, canals, and similar works, civil engineering is far less applied on farms than is mechanical engineering.

Although we did not see many evidences of soil blowing we realize that 1958 was a moist season. The hazard does exist in places and may be a threat in very dry years in parts of the new lands. Yet it seemed to us that unusual care was being taken to avoid cultivating hazardous soils.

Shelterbelts

We saw a good many shelterbelts and windbreaks, partly to protect crops from hot summer winds, partly to guard against soil blowing, and partly to control runoff.

In some ways recent experience with shelterbelts in the Soviet Union is similar to ours. Originally the idea in both countries was to have wide plantings in which natural regeneration could be expected. In both countries the tendency is now towards much narrower belts or windbreaks. In our country we are concerned with both summer winds and winter winds, whereas the Soviets are primarily concerned with hot summer winds.

Their recent experience suggests that the shrub rows should be eliminated in field windbreaks and the very lowest limbs pruned so that there is about a 24-inch space for the passage of air at the ground level. In the Krasnodar Krai, for example, with windbreaks of 2 to 4 rows they suggest a spacing in the grain fields of 25 times the height of the trees. With windbreaks tight at the ground level this spacing is reduced to 15 times the height of the trees. Actually, we saw only a few areas with windbreaks so closely spaced. One suspects that farm managers and chairmen are somewhat less certain of the value of windbreaks than are the agricultural advisers. Nearly all farms have them in the plan but many farms do not have them all on the ground. This may be partly a matter of "first things first."

Many of the windbreaks in the western part of the country were destroyed during the war and are only partly replaced. Since all farm animals are herded in the Soviet Union, we saw little damage caused by grazing animals, whereas that is one of the major hazards to American shelterbelts.

Soil Conservation Plans on Farms

Farm planning based on soil maps is generally good. By our standards these maps lack some in both cartographic and classificational detail. It was explained to us in Rostov that following the soil mapping, and any additional soil testing, plans were made for the farms cooperatively between the experts on the farms and those in the government. Disagreements and difficult situations were said to be ironed out in conference; and when the plans were finally agreed upon the chairmen of collective farms and managers of state farms were expected to adhere to them.

Because of the widespread knowledge of soil classification among the agriculturists, including the agronomists on farms, and because of the controls inherent in the Soviet system, we saw relatively few instances of soils unsuited to agriculture being used for agriculture. We were impressed in the new-land area, for example, with the care with which soils subject to serious hazards of drought, erosion, or blowing were avoided for field crops and the care with which they were maintained in vegetation. We saw very little overgrazing of grassland subject to erosion or blowing. Some of the other details of farm planning were carried on with less precision and accuracy than in the United States. Then too, we noted some significant differences between the plans and the actual cropping patterns on the ground.

Yet everything considered, basic soil conservation planning is firmly established in the Soviet Union. Based on our observations on farms and our discussions with responsible scientists and agricultural administrators, significant improvements may be expected, including increased yields and farm incomes. Increased labor efficiency depends on improved transport and marketing, and on alternative job opportunities for the present excess labor on many farms, as well as on education, research, and stable prices.

Besides the principal items on soil and water use to be outlined in some detail in this report, a few other observations and impressions are summarized as follows:

Water Conservation by Winter Protection

In northern Kazakhstan and elsewhere our attention was called to the use of tractor-drawn snow-ridging machines that pack the snow and push it into ridges about 15 to 25 meters apart in order to hold as much as possible on the fields. Claims are made for as much as 500 to 1,000 tons of additional water per hectare in the soil. Somewhat similar claims are made in some places for 2-row strips of sunflowers about 20 meters apart, sown when the fallow is last tilled. In the years when the ground freezes deeply before the snow comes, much of the melt water runs off. The practice of snow ridging might have some place on the nearly level soils of the northern Great Plains.

Education

The study group was impressed with the emphasis on education and scholarships. Government stipends are paid to good students attending both universities and institutes.

Besides attendance in regular day classes, many students prepare themselves in night schools and through correspondence courses. Many people on the farms study during their evenings and rest days and these obtain their diplomas as scientific agronomists, as animal husbandry officers, or as agricultural engineers.

The Soviets are training a great many women in several phases of agricultural science and practice, especially agronomy and animal husbandry. At the institutes for diploma graduates that we visited, about one-half of the students in these two fields were young women. Several women were found among the higher echelons of agricultural administration and in the research academies.

The great agricultural exhibition at Moscow (smaller ones are being set up in some of the republics) has great educational value. It makes possible a detailed view of all phases of agriculture throughout the whole of the Soviet Union.

We were also impressed with the facilities for abstracting all significant foreign works into the Russian language. Many books are also translated. Then too, a high percentage of Soviet agricultural scientists read English. At the present time Soviet agriculturists are more familiar with American scientific literature than we are with theirs. As their agricultural research continues to expand it will become increasingly urgent that American agriculturists become familiar with their results and experiences.

General Status of Farms

Most farms have made big strides toward mechanization and electrification, especially very recently with the transfer of much heavy equipment and responsibility from the machine and tractor stations to the farms. Some collectives are poor and are not electrified and are short on machinery. The big machines, especially crawler tractors and heavy combine harvesters, are symbols of modern progress to many Soviets. We saw some excellent machines including those required for accurate placement of fertilizers at seeding time for corn and cotton and for applying supplemental fertilizers later. We saw excellent machines for making ditches and other works of improvement. Certainly part of these were testing models and not widely produced. Many farms have milking machines, carriers on tracks for silage, and other carriers to remove the manure from the barn.

Yet other aspects of farming operations are far from modern. On most farms, for example, the manure is pitched by hand into small wagons, hauled to the field by horses, unloaded in piles, and spread on the soil by hand. Many of the dairy cattle are fed green-cut fodder, and much of this is cut by hand and hauled to the barn in small animal-drawn carts. At the same time, we saw modern silage harvesters that fed into the trucks that hauled the silage to storage. In places, much handwork with short-handled hoes is done to control weeds in vegetables, cotton, and other row crops.

The collective farms vary widely in income. Those that we examined were, of course, somewhat better than average. Including both payments in cash and payments in kind, a standard workday unit ranges from around 7 or 8 rubles to 25 or 26 rubles.[2] We have no doubt that some are

[2] Very roughly, 10 rubles correspond to 1 dollar.

lower. The problem of these low-income collective farms has led to the concentration of management skills by the consolidation of collective farms. Local citizens are aware of these poor farms and apparently the Communist Party helps the collectives select competent chairmen for improved management.

The amount of labor on many farms seemed excessive to us. Some chairmen of collective farms agreed they could operate with considerably less labor. But of course this situation cannot change until there are more factory jobs and other economic opportunities for people now on collective farms.

Living standards vary considerably, depending upon income. Generally they are lower than the living standards on commercial farms in the United States, but they are very much better than those common in the villages of southern Asia. Many of these farms had difficulty in building houses for their people immediately after World War II. On the more productive collective and state farms these old houses are gradually being replaced with considerably better ones. A typical new one-family house has a living space of about 60 square meters. It has a metal roof, good windows, and warm walls. A few may even have small refrigerators and other conveniences,

Deficiency of transport is a serious limiting factor to agriculture in the Soviet Union. The country is very large and the rivers are nothing like so helpful as those in Western Europe and in central United States. Thus transport is difficult for getting to the farms such supplies as lime, lumber, fertilizers, and machinery. And, of course, it is difficult to transport the farm products promptly to the places where they are required. For some reason the Soviet Government has not placed a high priority on highway construction. The roads to most farms are ungraded and are either very muddy and rough or very dusty and rough. This means that most trucking is done by relatively small trucks of 2 to 5 tons. Because of these serious limitations of transport, it is difficult to get building materials for houses in many places. It has resulted in the inefficient production of some crops, such as fruits and vegetables, in places not well suited to them.

Agricultural Potential

The people of the Soviet Union have plenty of room for both vertical expansion on their present farms and for areal expansion onto good soils. No doubt a great deal more cropland will be made available through drainage and irrigation and a good deal of present cropland will be improved by these practices. Planting of shelterbelts will help some to protect crops against hot winds. But agricultural planning will need to take account of the climatic risks.

Barring some catastrophe, Soviet farms will increase production substantially, especially in animal products, vegetables, fruits, sugarbeets, and other industrial crops. No doubt they could produce considerable grain for export. These increases will depend on increased supplies of fertilizers, machinery, and the like, on better and more rapid transport, and on more adequate processing of agricultural products, including refrigeration.

The farms in the Soviet Union are very large. In the time available it was not possible to obtain all details of operation on any of them. There are somewhat less than 90,000 farms in the whole of the USSR. During the interviews it was not always possible to distinguish clearly between actual performance now and the plan for the farm. As examples, descriptions of two farms are given as follows, one a collective farm near Kiev and one a state farm near Andizhan:

October Collective Farm

The October Collective Farm is located in Brovarskovo Raion of the Kiev Oblast, about 30 kilometers north of the city of Kiev. The farm was originally established in 1928. In 1934 all the peasants of this village were collectivized. Prior to World War II, the area presently encompassed by this collective was occupied by four collective farms. The farm suffered severe damage during the war and lost their livestock to the Germans. In 1950, when enough machinery was available, these four farms were combined into one collective farm. The chairman of the farm, Ivan Mikhailovich Kolbasinski, gave the study group a brief description of the collective and we toured some of the fields with him and part of his staff.

Labor Force.--The farm had 1,200 families with a total population of 5,000 people. There were 1,400 able-bodied workers on the farm. The chairman said that 18 people were involved in the administrative force. There were 11 people on the management board, 9 of whom worked also in the fields. The farm had one agronomist.

Machinery.--This farm had 14 tractors, 9 combines, 22 trucks, 1 car, and other machinery and equipment. The farm and villages were said to be completely electrified.

Crop Areas[1].--The collective farm occupied a total area of 6,400 hectares of which 3,800 hectares were under crops and 750 hectares under pastures and meadows. The total grain area was 2,000 hectares of which rye and wheat took up 1,200 hectares and the remaining 800 hectares were under oats, barley, and buckwheat. The lupine area was large because of a nitrogen deficiency in the soil, and was used for green manure as well as for cattle feed. There were also 500 hectares under potatoes and 200 hectares under cabbages, tomatoes, onions, table beets, carrots, and cucumbers. Orchards took up 170 hectares and 52 hectares were for a fruit-tree nursery. This farm supplied other farms in the area with young fruit trees.

The average size of each collective farmer's private household plot was 0.5 hectare although it ranged from 0.3 to 0.6 hectare. There was no irrigation on this farm. The average annual rainfall falls between 550 and 600 millimeters. The normal dry months are May and June.

Soils and Fertilizers.--The soils on this farm were said to be quite variable. The majority of the soils were called light clay loams, which would probably be called fine or very fine sandy loams in the United States. Most of the soils were of the Gray Forest group developed on the third terrace above the Dnepr River. (These soils are described in the section on soil classification.) The organic matter was given at 1.5 percent. The farm had some dark-colored (Humic Gley) soils in the lowlands and some Alluvial soil near a small river. Although the Humic Gley soil was cropped, it would have obviously benefited from tile drainage.

The soils on this farm were considered by the Soviets to be deficient in nitrogen, phosphorus, and potash. About 1,150 metric tons of mineral fertilizers were applied annually, consisting of 350 tons of nitrogenous fertilizers, 150 to 200 tons of potash, and 600 tons of phosphate. The chairman said that the potatoes responded well to applications of potash fertilizers and he hoped to increase the outlay of potash to 400 tons. The farm purchased ammonium nitrate for 150 rubles per ton, superphosphate (18 to 20 percent P_2O_5) for 40 rubles per ton, and 30-40 percent potassium salts at 50 to 60 rubles. The soils of this farm were mapped in 1953.

The farm had a map showing the lime needs divided into 4 categories as follows:

(1) No lime required. (This covered only a small area.)

(2) 1 to 2 tons per hectare required.

(3) 2 to 3 tons per hectare required. (The largest area.)

(4) 3 to 4 tons per hectare required.

Crop Yields.--The long-range wheat yield on this farm had been 18.5 centners per hectare. In 1957 it was 33.5 centners per hectare. The chairman estimated a yield of about 28 centners per hectare in 1958. He expected to obtain average yields of 30 centners per hectare due to the regular use of lupine and fertilizers. The wheat variety Belotserkovska 37 was grown on this farm.

A visit to the fields indicated that very little erosion or soil blowing was evident. The potatoes

Wheat on October Collective Farm near Kiev that will yield around 45 bushels per acre. Left, Chairman Ivan M. Kolbasinski; right, agronomist for farm.

[1] See approximate conversions at the end for converting metric units to American ones.

appeared uneven, probably due to careless spreading of manure. Some fields showed nitrogen deficiency. A field of wheat looked good and probably would yield about 45 bushels to the acre. It was a soft winter wheat with short straw and good heads. The chairman said it would yield 35 centners per hectare.

Livestock Production.--This collective farm had the following livestock inventory:

Cattle....... 1,300, of which 550 were milk cows
Hogs .... 2,000 to 3,000
Horses 350
Poultry.....11,000
Beehives... 350

The principal cattle breed was the Simmental, a dual-purpose breed. The average milk yield in 1957 was 3,521 liters per cow. For every 100 hectares of agricultural lands, the milk output came to 289 centners. The highest producer gave 6,500 liters.

Farm Income.--In 1957, this farm received a total income of 8.2 million rubles. Prices received from the government for required deliveries in 1957 were 29 rubles per centner of wheat, 27 rubles per centner of rye, 60 rubles per centner of vegetables, and 35 rubles per centner of potatoes. For deliveries after the required amounts were fulfilled, the farm received 110 rubles per centner of wheat and 95 rubles for rye. This farm sold about 90,000 fruit trees annually to other collective farms from its nursery at a price of 4.5 rubles each. Price for apples obtained at collective farm markets was 4 rubles per kilogram. The orchards provided about one-half of this farm's income. The farm chairman said that in 1958 there would be one price for all grains delivered to the government.

In 1957 each labor day[2] earned by a collective farmer was worth 2.0 kilograms of grain (for a total of 1,200 tons paid out to farmers), 2.5 kilograms of potatoes, 1.0 kilogram of vegetables, 2.5 kilograms of forage crops, and 7 rubles in cash. He expected a better return in 1958 and the cash return would probably be increased to 10 rubles.

Savay State Farm

This farm is located 45 kilometers northeast of the city of Andizhan, Andizhan Oblast of the Fergana Valley of Uzbekistan. The farm is situated very close to the border between the Uzbek and the Kirghiz Republics. This farm was established in 1929 in the desert steppe (Sierozem) region. Its development was made possible by the construction of the Sharikansai irrigation canal in 1928. The name "Savay" was adopted after the name of a Kirghizian who lived in the region a long time ago and was the first irrigator of note.

[2] Each worker on the collective farm gets a certain number of labor-day units for 8 hours of normal work, according to the skill required on his job. Thus an unskilled worker may get three-quarters of a labor-day unit for an 8-hour shift and a more highly skilled worker may get 2 or even more labor-day units for 8 hours of work normal for his job. On the collective, a member receives both cash and kind according to the number of labor-days he has to his credit.

The manager of this state farm, Mr. Abazmatov, met the study group, gave us a description of it, and showed the study group about the farm.

Population and Labor Force.--The farm has 2,700 families with a total population of about 8,000 people. The number of able-bodied workers is 4,500, of which about half are women. Workers begin to work at the age of 18. Women are permitted to retire between the ages 50 and 55 and men between the ages 50 and 60. In 1957, this farm sent about 30 young people to higher educational institutes. In 1958, 45 people from the farm graduated as mechanics from middle technical schools.

The farm has 15 agronomists, 3 irrigation engineers, 4 animal husbandry and veterinary experts, and 5 mechanical engineers.

The farm's labor force is divided into 10 labor sections, of which 1 is a livestock section. Each section has a mechanic in it who is a graduate of a technical school. As an example of how a section is organized, the manager provided the following information:

The first section is divided into 6 brigades which are responsible for:

430 hectares of cotton
30 hectares of hybrid corn
20 hectares of corn for silage
31 hectares of alfalfa for hay
15 hectares of alfalfa for green silage
26 hectares of alfalfa for seed
1 hectare of potatoes
2 hectares of vegetables and melons
2 hectares of orchards and vineyards.

Each field brigade has from 15 to 20 people in it and 2 tractors. Three or four members of each brigade are responsible for irrigation. Besides the field brigades, this first section has 2 mechanized brigades with 8 to 10 people in each. Each brigade follows its labor task depending on its specialty; for example, a cotton brigade does the work on cotton in this crop rotation. Each section has its own crop-rotation plan.

Of the three irrigation engineers, one is the chief engineer, one is responsible for distributing water amongst the sections, and the third is responsible for the maintenance of the installations.

Every section has an agronomist who directs the time of irrigation and the quantity of water to be used. The chief agronomist of the state farm, however, has the final voice in these matters. He develops the plan from the suggestions of the sections. The chief engineer plans the water system to carry out this plan.

The manager of the farm has three vice managers, one of which is the chief agronomist, one the chief engineer, and one the business manager. He also has a chief bookkeeper and 5 assistant bookkeepers at the headquarters staff. The planning department has two people employed. The farm has a central machine shop for capital and minor repairs. This shop employs 30 people. About 100 workers are in the building and construction department. In addition, every section has its own staff consisting of an agronomist, a mechanic, and a bookkeeper.

Norms and Salaries.--The basic salaries of workers depend on their position of responsibility. A brigade leader is paid 500 to 700 rubles per month. If the plan for his brigade is overfulfilled he receives a premium that raises his monthly salary to 900 to 1,500 rubles per month, depending on the extent of overfulfillment.

An irrigator receives a basic salary of 700 to 1,000 rubles per month. When he fulfills his quota of 0.7 hectare per day, he gets 26 rubles. If he irrigates double this norm, or irrigates 1.4 hectares, he gets 150 percent of the base pay, or 39 rubles.

The common laborer on the farm gets 17 rubles for fulfilling his norm.

The manager of the farm gets a basic salary of 2,700 rubles per month. When the plan is overfulfilled he receives about 4,000 rubles per month.

Crop Areas and Yields.--The total land area of this state farm is 8,000 hectares of which 6,500 hectares are under irrigation. Private plots of farmworkers total 320 hectares. The crop areas are as follows, in hectares:

Cotton	4,300
Alfalfa for hay	315
Alfalfa for silage	417
Alfalfa for seed	150
Corn for grain	230
Corn for silage	208
Oats and alfalfa	424
Potatoes	20
Vegetables	10
Melons	25
Orchards and vineyards	50

The 1957 yield of seed cotton was 25.6 centners per hectare. The 1958 yield plan was set at 26 centners per hectare but they hope to get 28 to 29 centners per hectare.

Alfalfa yields average 60 to 70 centners of hay per hectare when there is insufficient water but in 1958 about 90 centners per hectare are expected.

Fertilizer Consumption and Practices.--Mineral fertilizers on cottonfields are applied at the rate of 126 kilograms of nitrogen, 30 kilograms of potassium chloride, and 117 kilograms of P_2O_5 per hectare in three applications. Azobacter is not used. Alfalfa fields are given from 120 to 150 kilograms of P_2O_5 per hectare, applied at the time of disking. (The practices are described in some detail in the section on mineral fertilizers.)

During the course of the visit to the cottonfields, the manager of this state farm arranged for a demonstration of the application of fertilizers in a cottonfield. Two parts by volume of dry-sieved manure were mixed with one part of superphosphate (18 percent P_2O_5). Another pile contained ammonium nitrate (34 percent nitrogen). The machine used for application is a tractor-mounted cultivator with a fertilizer attachment. This consisted of two circular containers about 36 inches across, each with a board in the middle to separate the mixture of manure and superphosphate from the ammonium nitrate. There was a total of eight outlets or a pair for each row to be fertilized. Therefore four rows of cotton may be fertilized at once. The reason given for mixing dry manure and superphosphate was that, according to Lysenko, the phosphorus is made more available.

Some potassium is included in the fertilizer application on those cottonfields following alfalfa in the rotation.

Irrigation.--The manager considered the soils on his farm to be nearly ideal. Generally the soil is silt loam or silty clay loam about 2 meters deep over gravel. The water table is about 20 meters down. Average precipitation during the growing season is 35 to 40 millimeters. In 1958 90 millimeters had already fallen at the time of our visit, August 11. Generally, irrigation is done 4 to 6 times during the season with about 800 to 1,000 cubic meters of water per hectare during each application.

Cotton Production.--The cost of production was given at 1,550 rubles per metric ton of seed cotton. The price received from the government is 1,800 rubles per metric ton of seed cotton. The farm buys its cottonseed from the government. The rate of seeding, in checkrows, is 50 to 60 kilograms per hectare. The farm also buys cottonseed cake for its livestock feeding.

The farm is now obliged to deliver cotton stalks to the Government. Some 1,500 tons were delivered in 1957 to a factory for conversion of the stalks into alcohol. Part of the stalks are left on the farm and used for fuel by the households.

Livestock.--The livestock inventory on January 1, 1958, was as follows:

Cattle	671 (598 as of Jan. 1, 1957).
of which milk cows	236
Hogs	1,211
Workhorses	650
Sheep	3,377

Many of the sheep are of the fat-tailed breeds and are gradually being replaced by a fine-wooled breed.

Sociological Aspects.--A large clubhouse, with a theater, was under construction on this farm. Many new houses for workers were also being built. The farm had a 75-bed hospital for the medical needs of its 8,000 people. A school for 1,200 children was located on the grounds. Both the hospital and the school were supported by the government, although the farm built the school buildings and furnished accommodations for the teachers.

The most important single aspect of soil classification in the Soviet Union is the degree to which the system is used. Not only soil specialists, but also agronomists, farm managers, and the various agricultural specialists of research institutions and of farms are familiar with the system. The system is applied through generalized maps of large regions for regional planning, as well as through detailed maps of individual farms as a basis for farm planning. There is a single system of soil classification for the Soviet Union, and this serves as the core of soil teaching in all educational institutions above the level of the secondary schools. The entire research program in soils is also oriented in relation to this system.

The basic research in this, as in other phases of soil science, is by the Dokuchaiev Institute of Soil Science in the Section of Biological Sciences of the Academy of Sciences of the USSR. Prior to 1949 the Dokuchaiev Institute was associated with the Section of Geography and still maintains contact with that section. The Section of Geography and Cartography of Soils of the Dokuchaiev Institute under Professor Erokhina employs 50 persons and is the largest section of the Institute. The Section of Genesis and Amelioration of Saline Soils under Professor Kovda employs 32 persons. A section on methods of detailed soil mapping under Professor Liverovski is only 4-1/2 years old but employs 12 people. These are the principal sections concerned with soil classification, genesis, and mapping. They deal with principles and with nomenclature; the application in the field is under other institutions.

The work of the Dokuchaiev Institute is carried out in Moscow and through field parties, the latter commonly in cooperation with research institutions of the Soviet Union or of the various republics, over which the Dokuchaiev Institute apparently exerts considerable technical control with respect to basic principles. The Institute publishes generalized soil maps of the Soviet Union as a whole as well as of the Republics or special regions. It also issues special reports, each devoted to a single topic, such as the Sierozem of Middle Asia or the soils of Mongolia. A new soil map of the world at a small scale was issued in 1957. A new soil map of the Soviet Union is being compiled at a scale of 1:1,000,000 using a standard legend already fixed. A soil map of Kazakhstan has been published at a scale of 1:2,500,000. There are also maps of provinces at 1:500,000 with accompanying monographs. A manual of soil surveying is being compiled to be published in 1959. Detailed farm maps are handmade in a limited number of copies by institutions of the respective republics or oblasts, but the classification and general principles of mapping are the responsibility of the Dokuchaiev Institute.

The Division of Soils of the University of Moscow also carries on an active research program in addition to its primary responsibilities as a teaching institution. There is a section on morphology, genesis, and classification of soils under Professor Kovda, which involves 40 persons, including 3 professors. A section on cartography and geography of soils under Professor Vilensky involves 10 persons. Research in these fields is commonly accomplished by field expeditions to new lands and special problems studied under special contract with the Ministry of Agriculture, maintaining closest cooperation with the Dokuchaiev Institute. Results are published as monographs on special subjects or technical papers, and the best work of students may be published in separate publications.

The Lenin Academy of Agricultural Sciences has major responsibility for applying research in the field. For soil classification, this involves, mainly, the development of methods of mapping state and collective farms and the preparation of supplementary agrochemical maps showing various single factors, such as phosphorus supplying power, pH, and salinity. Work of this kind may be carried out at the various research institutes under the Lenin Academy or at various institutes of the individual Republics or districts, but with responsibility for standards and principles vested in the Lenin Academy. Basic and applied research are seemingly distinctly separated--basic research is under the Academy of Sciences and the applied research under the Ministry of Agriculture. Although it was stated that the closest cooperation is maintained between these two organizations, there was some suggestion of competition and some indication that financial support under the Ministry may be greater than under the Academy of Sciences.

The training of soil scientists for research, including those in soil genesis and classification, is at the University of Moscow, which accepts annually 40 or 50 students in this division. Their training involves 5 years, 2 of which are in general soil science. The last 3 years are spent working in the specialty culminating in a major thesis. Between the second and third years, all students must take an excursion on soils, research, and agriculture. The most talented may remain as candidates for the doctorate after completing the 5 years. Graduates are employed mainly at field experiment stations of the Ministry or other research agencies.

Most soil specialists, including soil surveyors and technicians for collective and state farms, are trained at institutes under the Ministry of Agriculture. Among these, the Timiryazev Agricultural Academy in Moscow is the highest institution preparing specialists for agricultural work. There are others like it throughout the Soviet Union, such as the one visited at Stalingrad.

At Timiryazev some professors hold dual appointments with the Lenin Academy. The course involves 5 years with 70 percent on theoretical studies at the Academy and 30 percent in practical work on farms or at research stations. About one-third of those who apply are accepted, based on performance in an entrance examination, with preference to young men and women having a farm background.

At the Timiryazev Academy it was obvious why agricultural workers are familiar with the classification system. An excellent museum of soil science occupies a very large room and is complete with monoliths of the major soils of the Soviet Union in conjunction with pictures and diagrams of the landscapes and exhibits of the native vegetation. Monoliths of both virgin and cultivated soils are exhibited. These are apparently used intensively for teaching of all agricultural students, not just those specializing in soil science.

The soil classification system used is that developed by the old masters, with minor modifications to accommodate some refinement incorporated since 1920. The great soil group is the basic unit, involving such names as Chernozem, Chestnut, Sierozem, and Podzol soils. The concepts appear to be strongly biased in terms of genesis. Various varieties of each group are recognized, such as Light Gray, Gray, and Dark Gray Forest soils or leached, podzolized, thick, ordinary, and Southern Chernozem. These are the basic units in the legends of generalized soil maps of regions and of the Soviet Union. They are also the basic units used in teaching at the college and high-school level and are the primary units used in the development of soil-research programs and in the interpretation of research results at the regional level. In them, one finds relatively little change from the nomenclature and concepts of the 1920's; and although the study group had no opportunity to investigate the concepts implied in detail or the degree of conformity of actual soil conditions to these concepts, one is left with the impression that authority of the classical soil scientists is a major consideration. In no case at any level, from that of the Dokuchaiev Institute to that of the collective farms, did the study group find evidence that the system itself, its units, or the concepts implied were being subjected to critical evaluation. At least to outward appearances, it was implied that the classification system and its use are a model of complete knowledge about the soils of the Soviet Union. This leads one to suspect that the facts may sometimes be subordinate to the model, though the study group had no concrete evidence to this effect.

The classificational units of detailed mapping are essentially, in American terminology, phases of varieties of great soil groups. The phase criteria are such features as texture, slope, degree of erosion, stoniness, and similar single factors. Legends of detailed farm maps have map units such as the following: Chernozem, leached, heavy loam; Chernozem, weakly podzolized, heavy loam; Chernozem, moderately podzolized, heavy loam; Chernozem, moderately podzolized, with deposition of heavy loamy material; Chernozem, gleyed, weakly podzolized, heavy loam. The soil genesis bias is very apparent in the basic units. Phase criteria are applied as modifiers to subdivide the broad varieties into units of agricultural significance.

To what degree the genetic and phase criteria have been integrated into a taxonomic system was not clear. There was evidence in the Ukraine that the units of farm maps in a given region are part of a more inclusive legend for the region as a whole. The soil map of one state farm, for example, carried an 86-unit legend, but only 12 of those units occurred on this farm. This suggests standard legends for at least fairly extensive regions. The extent to which such legends may be modified to fit conditions of individual farms was not clear.

Detailed soil maps are being made rapidly for individual state and collective farms at scales ranging from as large as 1:5,000 to as small as 1:20,000, depending upon the intensity of the agriculture. Some regions reported mapping complete; most, mapping incomplete but progressing rapidly. In all regions, mapping was reported to be planned for completion within a few years, rarely more than five.

The soil maps are made by specialists attached to local research stations. In White Russia, for example, it was explained that each oblast has a research station and each such station has a special soil service. This soil service supplies specialists for making the detailed soil map of each farm and, in addition, draws soil samples, analyzes them, and prepares supplementary maps showing levels of such single factors as phosphorus, organic matter, and salt. Using these as the basic information, planning maps are constructed for drainage, crop rotations, fertilization, and similar operations. All of the farms visited had such maps, with the exception of one in the new lands near Akmolinsk. All were on planimetric base maps, although we were told in some regions that the field scientists use aerial photos for their work. A very limited number of each farm map is made by hand, and there is no plan to publish at these scales in this detail. In addition to the soil units, the maps may carry supplementary symbols indicating depth to water table, erosion, or similar features not recognized in the map unit itself. Typically, the farm maps have a systematic system of coloring and cross-hatching or other cartographic devices designed to imply selected properties, generally what we would consider phase criteria.

Most of the maps seen did not carry a high degree of either cartographic or categorical detail. Most delineated areas were large. Legends typically involved 5 to 15 map units for areas of 3,000 to 10,000 hectares. Though the study group had no opportunity to check the mapping in detail, the character of the maps suggested either that soil patterns are relatively simple in comparison with those in many parts of the United States or

that the farm maps are considerably more generalized than those of the United States made for farm planning. At Poltava in the Ukraine, the cost of farm maps was estimated at 2 rubles per hectare, which is low relative to costs in the United States. It appears that the Soviet farm maps may be made on the assumption that specialists of the farms themselves are capable of recognizing conspicuous land features and making appropriate interpretations, in contrast to attitudes in the United States where farm-planning technicians ask that more information needed for farm planning be shown on the map.

The study group had an opportunity to see a number of profiles chosen as typical of certain soil groups, either in monoliths or in the field. These are discussed with descriptions, where available, in the following pages, and an attempt is made to correlate them with soils known in the United States.

Strongly Podzolized Soil[1]

This was seen as a monolith at Timiryazev Academy and is representative of a large area whose southern boundary is just south of Moscow. It was apparently a medium-textured soil having a very thin A_1 horizon, a very light colored A_2 horizon extending to 18 inches, and a distinct blocky textural B. The pH values were reported to be 4.5 to 5 in the upper horizons. Except for the low pH, the profile appeared to be very much like the Gray Wooded soils of northern Minnesota, Manitoba, and Saskatchewan. There was no zone of calcium carbonate accumulation, however.

Tundra Soils

These were seen as monoliths at Timiryazev Academy and involved a variety of different profiles, all with some degree of gleying, ranging from mineral soils with thin humus layers to moderately thick peat. The term is obviously applied to a vegetation zone and likely embraces many kinds of profiles.

Humus-Carbonate Soils

These also were seen only in monoliths. They were dark colored soils with thick A_1 horizons resting upon C. They occur as patches within the zone of strong podzols on materials very rich in lime. They would correspond to soils formerly called Rendzina in some soil literature.

Gray Forest Soils

Light gray, gray, and dark gray varieties are recognized and were seen as monoliths at Timiryazev Academy. As the names imply, the 3 varieties represent 3 degrees of color value of the surface soil. The light gray variety looked like a Gray-Brown Podzolic soil, and the dark gray would likely be called degraded Chernozem in the United States. In addition to these monoliths two profiles were seen in the field as follows:

Gray Forest Soil.--This profile was seen in the vicinity of Kiev on a nearly level cultivated area.

A_{1p}	0-7"	Dark grayish-brown (10YR 4/2) very fine sandy loam or coarse silt loam poorly graded; very weak fine granular; friable; smooth abrupt boundary.
A_3	7-10-1/2"	Brown (7.5YR 4/3) silt loam with common medium light-brown (7.5YR 6/3) mottles and vertical streaks of grayish-brown (10YR 5/2) silty material; very weak, fine and medium blocky; friable; wavy gradual boundary.
B_1	10-1/2-14"	Brown (7.5YR 4/4) silt loam with common medium distinct pinkish-gray (7.5YR 6/2) mottles. Weak, medium and fine blocky; friable; clear wavy boundary.
B_2	14-24"	Brown (7.5YR 4/4) heavy silt loam or light silty clay loam; moderate coarse blocks coated with light brownish-gray (10YR 6/2) silt. The coarse blocks are made up of weak fine blocks; friable; clear wavy boundary.
B_{31}	24-32"	Yellowish-brown (10YR 5/4) silt loam with vertical threads of 10YR 6/2 silty material; very weak subangular blocky; very friable; gradual boundary.
B_{32}	32-42"	Pale brown (10YR 6/3) silt loam; weak, very fine blocks coated thinly with 10YR 6/2 silty material; abrupt wavy boundary.
C	42-50" +	Light yellowish-brown (10YR 6/4) silt; structureless; calcareous.

Krotovinas 2-4 inches across filled with dark grayish-brown (10YR 4/2) material extend through the B and to the C horizon. This profile would probably be called a Gray-Brown Podzolic soil in the United States. The A_2 horizon, if present, had probably been incorporated in the plowed layer.

Dark Gray Forest Soil, Slightly Washed.--This profile was seen on the Poltava Provincial Agricultural Experimental Station near Poltava in the Ukraine. The pit had been dug on a 20-percent slope that had been in perennial grass for 18 years. The site was on the edge of one of the deeply incised dissection forms characteristic of streams in this region. These dissection forms have distinct slope breaks about half way between the undulating plain of the upland and the valley bottom proper suggestive of small pediments associated with two erosion cycles. The pit had been dug on the edge of this middle slope break. The profile was much more strongly expressed than one would expect on such a landscape and appeared more strongly developed than many soils we had seen on the loess plain at higher elevations. It would probably be considered a degraded Brunizem in the United States.

A_1	0-6"	Dark brown (10YR 3/3) silty clay loam; moderate, very fine, subangular blocky and medium granular structure; slightly firm; clear wavy boundary.
A_2	6-13"	Dark brown (10YR 3/4) silt loam; moderate medium prisms made up of weak medium and fine plates; friable; gradual wavy boundary.
B_{21}	13-21"	Dark brown (10YR 3/3) silty clay loam; weak coarse prisms composed of moderate, medium, and fine blocks with discontinuous light brownish-gray (10YR 6/2) coats; slightly firm; gradual boundary.
B_{22}	21-32"	Very dark brown (10YR 2/2) silty clay; very weak coarse and medium prisms composed of strong medium blocks with discontinuous light-brownish-gray (10YR 6/2) silt coats; slightly firm; gradual boundary.
B_{23}	32-40"	Grayish-brown (10YR 4/2) silty clay; moderate coarse prisms composed of weak medium blocks coated with very dark grayish-brown (10YR 3/2) thin discontinuous clay skin; firm; very gradual boundary.
B_3	40-55" +	Brown (7.5YR 4/4) silty clay loam; moderate medium prisms about 30 percent covered with dark grayish-brown clay skins and 70 percent with light gray (10YR 7/2) silt coats; firm.

[1] All the profile descriptions that follow were made by M. G. Cline.

The pit extended only to 55 inches and the C horizon was not seen but was presumably loess. We were told that the degraded Chernozem of this region would require lime at about 30 inches and that here carbonates occur at slightly more than 60 inches. The dark color and fine texture of the B_2 horizon suggest a relatively old soil, which might be consistent with the topographic position. Time did not permit thorough investigation of soils in this area to determine the exact nature of this profile. The soil scientists present did not appear to consider the possibility of discontinuity in material.

Chernozem

A number of varieties of Chernozem are recognized. Among these the thick Chernozem is considered to have more than 40 inches of A_1 horizon. The ordinary Chernozem has less than 40 inches of A_1, generally between 18 and 24 inches, including what we would probably call B_1, though it is dark in color. The so-called Southern Chernozem is lighter colored and has less thick A_1 horizon. In addition, there are varieties named for regions; such as Azov or Western pre-Caucasus Chernozem and others of comparable names. The study group had the opportunity to see 3 varieties, which are described below:

Thick Chernozem Intergrade to Ordinary Chernozem.--This profile was seen about 25 kilometers from Poltava on the road to Kharkov. The site was in a wheatfield, which had been seeded to alfalfa, on a nearly level plain.

A_{1p}	0-12"	Black (10YR 1/1) silty clay loam; strong fine granular; friable; pH 6.4 at 2 inches and 6.2 at 8 inches; gradual boundary.
A_{12}	12-22"	Black (10YR 2/1) silty clay loam; moderate medium and coarse granular to moderate medium and fine blocky; colors grade with depth to (10YR 3/1) at the bottom of the horizon; pH 6.9; friable; gradual boundary.
A_3	22-35"	Very dark grayish-brown (10YR 3/2) silty clay loam; very weak vertical cleavage surrounding weak fine subangular blocks; friable; pH 7; gradual boundary.
B_1	35-38"	A transitional horizon; dark grayish-brown (10YR 4/2) silty clay loam; weak fine subangular blocky; friable; gradual boundary.
B_2	38-54" +	Brown (10YR 5/3) silty clay loam; weak fine subangular blocky; pH 7.1; roots were numerous to the top of this horizon and a few extended to the bottom of the pit at 54 inches.

The entire profile to the bottom of the pit had many 2- to 4-inch diameter krotovinas filled with dark grayish-brown to very dark grayish-brown silty clay loam material. This region is said to have two loess layers. The profile seen was only in the top one. It would be a minimal Chernozem or Prairie soil by our standards, based on lack of distinct textural B relative to the A. The C horizon was not seen and, if silt, the solum is distinctly finer textured than the parent material.

Western Azov Chernozem or Pre-Caucasus Chernozem.--This profile was seen near Krasnodar in a fallow field on a nearly level terrace. The material may have been either loess or alluvial. The soil would probably be called a medial Chernozem in the United States.

A_{1p}	0-6"	Very dark brown (10YR 2/2) silty clay loam; moderate medium granular to fine subangular blocky; friable to slightly firm; abrupt smooth boundary.
A_{12}	6-19"	Very dark grayish-brown (10YR 3/2) silty clay loam; moderate medium granular; friable; gradual to clear wavy boundary.
B_{21}	19-33"	Dark brown (10YR 3/3) silty clay; strong fine subangular blocky; friable; clay skins apparent; very slight vertical cleavage enclosing the blocks; gradual boundary.
B_{22}	33-41"	Dark brown (10YR 3/4) silty clay; strong medium subangular blocky with moderate clay skin; very thin 10YR 6/2 silt coats on faces of a few blocks; friable; to slightly firm; plastic; clear wavy boundary.
C_{ca}	41-50" +	Dark grayish-brown (10YR 4/2) silty clay; strong medium and fine blocky; slightly firm; white threads of calcium carbonate throughout this horizon.

Normal Thick Carbonated Chernozem.--This was called a thick Chernozem though the thickness of the A_1 corresponds to the normal Chernozem as described by workers in Moscow. The profile was seen in the new land development about 80 kilometers northwest of Akmolinsk. In traveling from Akmolinsk to this site, one went through a region of Chestnut soils into this Chernozem belt. The material was apparently loess. The entire profile was calcareous, but the expression of the textural B suggests that the calcareous nature may have been induced after the solum had been developed, possibly by calcareous dust on the surface. Except for this calcareous characteristic the soil would be considered a well-expressed Chernozem in the United States.

A_{11}	0-1"	Very dark brown (10YR 2/2) silty clay loam; strong very fine granular; friable; held in a mass of grass roots; calcareous.
A_{12}	1-10"	Very dark brown (10YR 2/2) silty clay loam; moderate medium prismatic enclosing moderate medium and fine blocks; friable; calcareous; clear wavy boundary.
B_{21}	10-24"	Very dark grayish-brown (10YR 3/2) silty clay; strong medium prismatic enclosing strong medium and fine blocks coated with very dark brown (10YR 2/2) silty clay material; many fine roots; firm; calcareous; lower boundary clear and irregular, depth ranging from 20 to 30 inches within 4-inch horizontally.
B_{22}	24-42"	Brown (7.5YR 5/4) silty clay; very weak medium prismatic structure enclosing weak medium and coarse blocks; firm; plastic; many krotovinas; calcareous; clear wavy boundary.
C_{sa}	42-51"	Brown (7.5YR 5/4) silty clay loam with 1/4- to 1-inch spots of white (10YR 8/2) crystalline material presumed to be gypsum; structureless; friable; calcareous; clear wavy boundary.
C	51-82" +	Brown (7.5YR 5/4) silty clay loam; slightly lighter in texture than the overlying horizon; contains 1/4- to 3/4-inch spots of white crystalline material spaced 2 to 8 inches apart; structureless; calcareous.

This soil was on a nearly level plain that had never been plowed. The principal vegetation included about 65 percent Festucae sulcata, about 10 percent Stipa tinctorum, about 10 percent Artemesia, and various forbs. It was estimated that ground cover was about 60 percent. Within the area were many low mounds possibly 15 to 20 feet in diameter and 12 to 24 inches high. These were estimated to occur at about a rate of 2 per acre and were apparently built by rodents (marmots), probably those responsible for the krotovinas. A second pit in the same

Wheat on Chernozem in the new-land area near Akmolinsk.

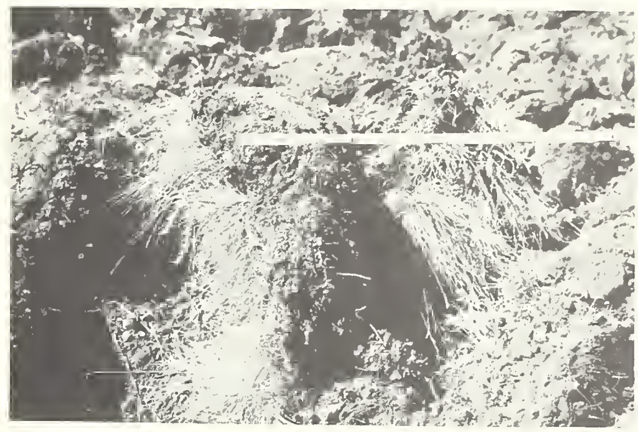
Plowing of virgin Chestnut soil in new-land area near Akmolinsk.

locality was seen but the soil was not described in detail. It resembled the first, but had a thinner A horizon. The gypsum spots were present in the substratum, and the same irregular character of the lower boundary of the A was very striking.

Chestnut Soil

Dark and light Chestnut varieties are recognized. Monoliths of the dark Chestnut soils seen at Timiryazev Academy approach the color of some of the Chernozem near the Chestnut transition in the United States, but the solum was only about 30 inches thick. The light Chestnut would correspond to the Chestnut and Brown soils of the Great Plains, more nearly Brown than Chestnut. One profile called a Meadow Chestnut soil was seen south of Stalingrad on a nearly level terrace that had been planted to cherries in 1949. We were told that the term "Meadow Chestnut" was applied to show the use of the soil. This explanation may have been misinterpreted through the translation. In most instances the term "meadow," as we had found it used, was applied to soils with high water tables. In any event, the profile seen was not wet; it was essentially a minimal Chestnut soil profile in at least three different deposits, in addition to material added on the surface during cultivation and leveling.

A_{1p}	0-6"	Very dark grayish-brown (10YR 3/2) fine sandy loam to loam; moderate fine granular; friable; abrupt smooth boundary.
A_{12p}	6-7"	A layer of undecomposed sawdust mulch and organic debris that had been plowed down.
A_{13}	7-13"	Very dark grayish-brown (10YR 3/2) uncrushed and 10YR 3/3 crushed loam. This is probably the original A_1 horizon; seemingly structureless in place; friable; wavy boundary.
B_1	13-26"	Dark brown (10YR 3/3) fine sandy loam; very weak fine granular; friable; no color change when crushed.
II A_{1b}	26-30"	Very dark grayish-brown (10YR 3/2) fine sandy loam; very weak fine granular; friable; clear wavy boundary.
II B_{2b}	30-37"	Brown (10YR 5/3) loamy sand; structureless; loose.
III A_{1b}	37-47"	Very dark grayish-brown (10YR 3/2) clay loam; very weak very fine granular; friable; plastic.
III B_2	47-58" +	Brown (10YR 4/3) sandy clay loam; very weak or no structure; friable.



Close view of recently plowed furrow slices of virgin Chestnut soil in new-land area near Akmolinsk.

This profile was so confounded by various depositions and by tillage on the surface that a very complete description was not taken. Buried soils are very common in the Stalingrad region, as seen in the dissection forms, and this is an example of the kind of profile one might expect to find. It is not a good example of the soils called Chestnut, though the people at the Stalingrad Institute had prepared this profile as a typical Chestnut soil.

Sierozem

Soils called Sierozem were seen in the vicinity of Tashkent, one on the Hungry Steppe and the other at the Akkavak Central Agro-Technical Station about 10 miles east of Tashkent.

The soil on the Hungry Steppe was not studied in detail. It would probably have been called a Regosol in the United States, and it is evident that the zonal soil name is derived as much from the climatic and vegetation zone as from characteristics of the profile. The soil was seen in a shallow pit in an area that was said to be undisturbed. The surface soil was about 5 inches thick and dark grayish-brown (10YR 4/2) with many white (10YR 8/1) salt flecks. Workers of the region thought the salts were principally

sulfates and chlorides. The pH ranged from 8.6 to 8.0 within the profile. There was no B horizon. In the adjacent irrigated area, the pH was 7.8 at 15 inches and 7.5 at 30 inches. The irrigation water itself had a pH between 9.0 and 8.5. It was a saline soil approaching a Solonchak-Sierozem intergrade.

Three profiles had been prepared in the same field at the Akkavak Station. They were on a gentle slope in irrigated land and had been prepared to demonstrate effects of erosion at the top of the slope and deposition on the lower sites. All were considered ordinary Sierozem. We could not measure differences in thickness of surface soils at the sites of the pits, and questioning brought out that the differentiation was based on knowledge that soil had moved in the irrigation furrows from the upper to the lower part of the slope. The soil in the lower position, however, had a slightly more strongly expressed textural B than that on the upper part of the slope, but this had not been noted by the workers at the station. The description that follows is that of the profile on the upper part of the slope.

A_{1p}	0-11"	Dark grayish-brown (10YR 4/2) silt loam; nearly massive; color 10YR 6/2 when dry.
B_{21}	11-18"	Brown (10YR 4/3) when moist; (6/3 dry) silt loam; very slight vertical cleavage enclosing moderate medium and coarse subangular blocks; very hard.
B_{22}	18-37"	Brown (10YR 5/3); (6/3 when dry); heavy silt loam; weak coarse prisms enclose weak to moderate coarse subangular blocks containing a few light gray specks; very hard.
C	37-57"+	Brown (10YR 5/3) moist; (7/3 dry) silt loam; common white lime nodules; very weak to moderate coarse prismatic; very hard; the greatest concentration of carbonates was between 37 and 45 inches.

The middle profile was essentially similar to that described, but between 32 and 59 inches there was a very high concentration of concretions of calcium carbonate one-quarter inch in diameter. At the lowest-lying profile no carbonate concretions were apparent above the bottom of the pit at 60 inches. All of the profiles were calcareous throughout. The workers of this station claimed they were basing their judgment that the upper profile was eroded and that the lower profile had had deposition on the fact that the depth to carbonates increased downslope. They had apparently not considered the possible variation in water available for leaching due to position on the slope.

Solonetz

The Solonetz has, of course, received much attention in the Soviet Union. Many Solonetz spots were seen in the Chestnut region in the vicinity of Akmolinsk and also with Chestnut and Brown soils in the vicinity of Stalingrad. It would appear from our conversation with a number of people and from what we were able to see in a few localities that any soil with strongly expressed prismatic structure, corresponding to soils we would call maximal Brown or Chestnut soils, is likely to be called Solonetz, in addition to soils having typical Solonetz morphology. We were shown one "Solonetz" soil in a pit near Stalingrad, which would probably be called a maximal Brown soil in the United States. This was described very hurriedly and incompletely.

A_1	0-4"	Grayish-brown (10YR 5/2) silt loam.
B_{21}	4-10"	Dark brown (7.5YR 3/4) clay; strong prismatic structure; friable; plastic.
B_{22}	10-16"	Brown (7.5YR 5/3) silty clay; weak medium prismatic; calcareous.
B_3	16-42"+	Light brown (7.5YR 6/3) silt loam; weak coarse prismatic; calcareous.

This profile was on a gently sloping area supporting a thin stand of Artemesia species and grasses.

Soils Having High Water Tables

Most such soils were called meadow soils, modified by a term such as Chernozem. One, however, in the Krasnodar area was called a Chernozem-like soil. Both would have been considered Humic Gley in the United States.

Meadow Chernozem.--This was in a badly disturbed area about 30 kilometers north of Kiev in the same general region as the Gray Forest soil previously described. The pit was filled with debris of buildings, and upon questioning, we learned that it had been the site of a town. Consequently, the description taken was made very rapidly and is incomplete.

A_1	0-20"	Black (10YR 2/1) silt loam; weak very fine blocky to coarse granular; friable; when crushed the color was 10YR 2/2. The depth to the bottom of this horizon ranged from 13 to 29 inches within the pit.
A/C	29-35"	Mixed A_1 and C material.
C	35"+	Light brownish-gray (10YR 6/2) silt loam with common medium yellowish brown (10YR 5/4) mottles and pockets of very dark gray (10YR 3/1) material in krotovinas.

This soil was calcareous from the surface. The soil scientists said the carbonates had been brought up through capillaries from calcareous material below, but the disturbance in this area leads one to question this assumption. It was called a gleyed meadow Chernozem but is probably not representative of such soils except for the gleying.

Chernozem-like Soil.--This was considered the ideal soil for rice in the Krasnodar area. A pit had been dug but had filled with water to within about 15 inches of the surface. As best we could tell from clods that had been thrown out of the pit, it had an A horizon about 15 inches thick that was black (10YR 2/1) clay, massive, with few to common fine 10YR 5/4-5/6 mottles. This had been puddled for rice but was in alfalfa at the time observed. The subsoil material, presumably a B_g, from 15 to about 30 inches was very dark gray (10YR 3/1) clay with common fine strong brown mottles. It appeared to be essentially massive and was reported to be nearly impermeable to water. Below about 30 inches was highly mottled clay containing 1/4- to 3/8-inch lime concretions. We were told that the gleying appeared in the B after

irrigation had been applied and that the water table was 2 to 3 meters below the surface prior to irrigation during the dry season. It was said that water is now under hydrostatic head below the B and comes to the surface only when the B is broken. At the present time this would probably be considered a very fine-textured Humic Gley in the United States.

Organic Soils

These were seen in the vicinity of Minsk in areas being reclaimed. No detailed descriptions were taken but the soils correspond very well to Carlisle muck as it is mapped in the Northeastern and Middle Western States. The surface was highly humified and, where undrained, raw wood, sedges, and reeds made up the material at depth. Where it had been drained for a considerable time, the material was well humified to considerable depths. The pH values were relatively high, generally 6 or more.

In summary, the soil classification of the Soviet Union is being used very intensively throughout the areas visited. Soil maps for farm planning are being made rapidly, seemingly somewhat less detailed than those in the United States and using map units that are essentially phases of varieties of the great soil groups. The classification system itself is that of the old masters, relatively little modified since 1920. It would appear that the system may not have been subjected to critical appraisal and that to some degree its application is by authority. Nevertheless, it is being used widely for practical objectives, seemingly with much success.

LABORATORY RESEARCH IN SOIL SCIENCE

Although studies of Soviet research in soil laboratories were not one of its primary objectives, the study group did visit some of the laboratories where both basic and applied soil research were in progress.

Generally Soviet soil laboratories have instruments and equipment similar to those in American laboratories. Photoelectric spectrophotometers and colorimeters were seen in most of the laboratories, and we were informed that 500 electron microscopes were manufactured in the Soviet Union last year. Yet most laboratories had less modern equipment than most American laboratories. Wherever routine soil or plant analyses were being done, at least some of the older gravimetric and volumetric methods were in use. The number of subprofessional assistants in the Soviet laboratories was higher than in those of the United States. The availability of assistants, probably on modest salaries, has undoubtedly had its effect on analytical procedures and laboratory instrumentation. For example, even in the new and very modern soil laboratories at the University of Moscow a number of hand-operated vacuum pumps were in use.

Radioactive isotopes were in use in many of the research institutes visited and the scalers, monitors, and survey meters in these laboratories appeared to be comparable to United States instruments. Safety regulations for the use of isotopes seemed to be more lax than in the United States. On several occasions our entire study group, and the Soviets accompanying us were brought into rooms where counting was in progress. At a hydrotechnical laboratory in Minsk, we visited one laboratory where an emission spectrograph and densitometer, 3 scalers for counting isotopes, a setup for potentiometric titrations, and the desk of a senior research worker were all housed in a room about 15 by 20 feet.

Dokuchaiev Institute of Soil Science

This has long been the highest soil research institute in the Soviet Union. It is a constituent part of the Academy of Sciences of the USSR. The Institute has sections on (1) soil geography and cartography, (2) genesis and amelioration of saline soils, (3) agrochemistry, (4) soil mineralogy, (5) biochemistry and microbiology, (6) soil physics and technology, (7) physical and colloidal chemistry of soils, (8) chemistry of soils, (9) soil hydrology, (10) soil erosion, (11) methods of detailed soil mapping, and (12) soil biology. Academician I. Tyurin is the Director. Some staff members also hold chairs in the Pedology Department of the University of Moscow.

The Journal Pochvovedenie is edited at this Institute; and many bulletins and monographs on the work of the Institute are also published.

The research program is not confined to the laboratories. Many of the Institute staff conduct fieldwork throughout the Soviet Union, especially regional studies of soils that lay the basic principles for detailed soil mapping and other applied soil research. United States Department Of Agriculture Handbook 60, Diagnosis and Improvement of Saline and Alkali Soils, is being translated for use at this Institute and for instruction at the University of Moscow.

Discussions in some detail were held with Professor Sokolov, in charge of soil chemistry research at the Dokuchaiev Institute. Professor Sokolov is doing some work on measuring available phosphorus in soils by exchange with P^{32} in solution, and seemed to be well posted on similar work in Britain and in the United States on this topic. By using radioactive phosphorus, he had concluded that plants can obtain nutrients from highly saline zones in the soil provided a part of the root system is in a nonsaline moist soil.

Using the same technique, he had confirmed that plants do not obtain any significant amount of nutrients from dry soil layers even though another part of their root systems may be in a moist but infertile layer.

Department of Pedology (Soil Science) in the University of Moscow

Although lectures in soil science began in 1806, this department was fully established in 1921. It is now housed in fine new and very well equipped laboratories on the new university campus. Professor Victor Kovda is head of the department. Six chairs, or professorships, are established in the various phases of soil science somewhat the same as in the United States. Besides research laboratories, they have excellent museums and other equipment for teaching.

The central part of the new center for the University of Moscow, built since World War II.

Professor N. A. Krasilnikov, in soil microbiology, is conducting some interesting work with plant toxins and stimulants produced by organisms in the soil. Apparently giberellin is the only growth stimulant worked with to date. A plant toxin said to be produced by fungi was the subject of an experiment shown to some members of the study group. The substance responsible for the effect has not been identified. Paper and column chromatography were being used to isolate this and other compounds from soil. A technique employing oat seedlings grown in petri dishes was being used to detect the presence of the toxin in sterilized samples of soil. Growth of the seedlings was sharply reduced in samples said to contain the toxin. Professor Krasilnikov reported that the toxin was adsorbed by soil particles but retained its toxicity after adsorption.

In the soil physics laboratory, elaborate equipment for studying the heat capacity of soils and heat transfer in soils was observed. There was also equipment for studying the coefficient of friction of various metals with various soils.

Several two-student laboratories for graduates were well equipped. Up-to-date instruments were in use for chemical analysis. No instruments for measuring soil-moisture tension were in evidence. Yet, on the whole, few university departments of soil science in the world are better equipped for research and teaching.

All-Union Institute of Fertilizers and Agro-Chemistry in Moscow

This Institute is located on the grounds of the Timiryazev Academy and is administered by the Lenin Academy of Agricultural Sciences. The Moscow staff numbers about 200 people. The Institute apparently has a major role in the coordination of applied soil research throughout the Soviet Union. A plan for a fertilizer experiment to be conducted at locations throughout the Soviet Union was presented to the study group. Groups working with such problems as the amelioration of Solonetz soils and the fertilization of cotton in Middle Asia are attached to this Institute.

There is also some work in fertilizer evaluation. They have studied defluorinated rock phosphate, calcium metaphosphate, and liquid ammonia, and are currently studying urea. Composting of peat with liquid ammonia was under investigation.

The Institute contained a well-equipped section for the use of radioisotopes and reported that they were working with P^{32}, Ca^{45}, Co^{60}, Sr^{90}, and S^{45} and just starting work on zinc.

N. P. Karpinski of this Institute is studying the phosphorus supplying power of soils. He was familiar with the "A" value concept of Lyman Dean and the calcium phosphate potential work of Dr. Schofield of Oxford. He was using exchange resins to extract phosphorus from soils similar to C. A. Black's work in the United States. Some work on organic phosphorus was underway using H_2O_2 oxidation to determine organic phosphorus.

The laboratories on soil organic matter are working on methods of composting, and also studying the effect of specific organic compounds on plant growth. They reported that application of 1 mg. of certain compounds derived from humus per kilogram of soil gave considerable increase in plant growth.

Belorussian Scientific Research Institute of Amelioration and Water Utilization in Minsk

This Institute was founded in 1930 on the grounds of a former institute for swamp reclamation. S. G. Skoropanov is the Director. They have a large laboratory and office in Minsk, a field station near Minsk, and two other large field stations. The work centers primarily around the reclamation of peat soils. The professional staff numbers 150, of whom nearly one-half are engineers.

This Institute reports that they have used radioisotopes of sulphur, rubidium, and chlorine to measure the rate of movement of drainage water in field soils. This was done by placing the dissolved isotope in a well in the field and sampling the water in test wells located in a circle around the first well. P^{32} was in use in laboratory

studies of adsorption of phosphorus in soils. They report that aluminum phosphates are the principal adsorbed form in Podzol soils.

An elaborate setup of equipment for measuring the physical properties of peat soils, such as internal friction and shear resistance, was visited. They were also using tensiometers to measure "the capillary attraction of different peat soils for water." This was the only use of the soil-moisture tension concept we noted during our visit.

An outdoor lysimeter setup for studying the effects of depth of water table on crop yields from organic soils was observed. Water-table depths were controlled by outlets of variable heights. Water was added to the surface of the lysimeters daily.

All-Union Scientific Research Institute on Corn at Dnepropetrovsk

This is a new Institute and is primarily concerned with applied research to guide Soviet expansion of corn production. In the studies of nutrition of corn, the staff of this Institute reported a depression of corn yields resulting from long-continued applications of phosphate fertilizers without high levels of the other nutrients, especially nitrogen. Laboratory work on the water requirements of corn was observed. Apparently the research workers here were attempting to study water utilization and requirements without full consideration of the atmospheric factors involved.

Akkavak Central Agro-Technical Station Near Tashkent

This station is under the USSR Scientific Research Cotton-Breeding Institute, sometimes referred to as the Middle-Asian Cotton Research Institute. All of the work is related to cotton production and most of the effort is toward applied research. In the plant physiology laboratory work was underway on the physiology of cotton-boll development. Due to their short season, the Soviets say they harvest unopened cotton bolls, store them at elevated temperatures, and then open them and remove the cotton by machine. Studies of the temperature and humidity requirements of the bolls during this storage were underway. They report useful fiber from bolls 7 days old or older.

In outdoor pot experiments the effects of nitrogen on boll development were being investigated. Bolls formed at the same time were selected on each of the various nitrogen treatments, then the plants were pruned so that each of these selected bolls would be exposed to nearly full sunlight. This technique was used to eliminate differences in light and temperature on the bolls arising from the increased degree of shading on larger plants due to nitrogen fertilization. The investigator in charge felt that this technique would eliminate the confounding of nitrogen, light, and temperature effects in his work on boll development.

There were a number of other nutritional experiments with cotton in the same setup of outdoor pot experiments. Although there were as many as six pots for each treatment, all pots of the same treatment were located in one spot, rather than according to a randomized block design.

Experiments to study fertilizers and other treatments of cotton at the Akkavak Central Agro-Technical Station near Tashkent.

The staff of the Institute reported that application of phosphorus on cotton could reduce the transpiration coefficient independent of its effect on yield.

Summary of Observations in Soil Laboratories

Little of the work observed in Soviet soil laboratories suggested the use of concepts that are not known in the United States. Soviet research workers were generally much better informed on American soil research than their American counterparts are on Soviet work. American research publications were in evidence at many institutes.

Several of the research administrators interviewed expressed the belief that soil microbiology should receive greater emphasis in the USSR. The work at the University of Moscow on plant growth toxins and stimulants of microbial origin seems to merit close study by American soil scientists. A generally better coverage and familiarity on the part of Americans with Soviet scientific research will probably become increasingly more urgent as the expanded Soviet efforts in soil research continue.

CROP ROTATION SYSTEMS

Long rotations with many different crops in each rotation are very common in the Soviet Union. On many farms visited by the study group, 10-year rotations with five different crops were reported to be in use. The large number of different crops is probably the result of diversification made

necessary because the transportation system is inadequate to permit regional specialization in crop production. Our observations indicate that weeds are perhaps a more serious problem and soil erosion a less serious problem in the Soviet Union than in the United States. Agricultural production on each farm must be in accordance with the national and regional plan. All of these factors have probably influenced Soviet thinking on crop rotations.

We saw few good rotation pastures of perennial grass-legume mixtures in the Soviet Union. In many instances livestock were being herded on stubble aftermath. Much green-cut fodder is used. Good permanent pastures were seen only on wet lowlands and in the new-land area around Akmolinsk. In the Akmolinsk area, ranges dominated by grasses of the Stipa genus were in excellent condition. Apparently livestock numbers in the new-land area are low in relation to the acreage of native grass.

The Soviets use the term "clover fallow" to cover the practice of seeding clover with spring grain, allowing the clover to grow until after the first harvest the year following seeding, and then plowing it down before a fall-sown crop. They use the term "occupied fallow" to cover the practice of growing a short season crop (usually corn) for silage or for soiling in place of fallow in their rotation systems. The distinction between "occupied fallow" and any other silage production was not clear. In their rotation discussions, "perennial grass" refers to grass-legume mixtures.

Rotation Studies at Research Institutes

In discussing crop rotations, the staff of the Institute for Fertilizers and Agro-Chemistry, located on the grounds of the Timiryazev Academy at Moscow, indicated that the general trend in the USSR is away from green manures and toward more feed crops and barnyard manure. They said their data show that clover grown for 1 year at two different places in a long rotation is superior to a 2-year stand of clover grown just once in the same rotation. The staff of the Institute expressed the opinion that commercial nitrogen may eliminate the need for green-manure crops on many soils.

Corn that will yield about 75 bushels per acre at the Poltava Provincial Agricultural Experiment Station. This corn is grown in rotation with alfalfa on slightly washed Gray Forest soil.

The study group saw only one experiment on crop rotations. This was at the Poltava Provincial Agricultural Experimental Station and was located on a nearly level dark Gray Forest soil (degraded Brunizem in the United States system) of silt loam to silty clay loam texture. The experiment was a study of different versions of the following 10-year rotation: (1 and 2) Perennial grass-legume mixture, (3) winter wheat, (4) corn or sugarbeets, (5) spring-sown small grain, (6) corn for silage, (7) winter wheat or rye, (8) corn or sugarbeets, (9) spring grain, and (10) winter wheat. Apparently the plan for this experiment called for each crop to be grown each year, but we received no other information on its design. Perhaps it was more a plan for testing than an experiment. The layout was well tended. The staff of this station has concluded that 1 year in 10 of perennial grass-legume is adequate for these soils.

On the experimental farm of the Belorussian Scientific Research Institute of Amelioration and Water Utilization near Minsk a 9-year rotation is used on the peat soils. This rotation is as follows: (1) Clover-timothy mixture, (2) cabbage and potatoes, (3) winter rye, (4, 5, 6) clover-timothy mixture, (7) sugarbeets, vegetables, or other row crop, (8) spring grain, and (9) hemp or sugarbeets. The yields on this farm appeared to be about as good as those on similar soils in the United States. Oats and barley on variety test plots looked especially good. With this cropping system and the installed drainage, the depth of organic soil has decreased from an original depth of 1 to 2.5 meters to a depth of 60 centimeters to 2 meters after 40 years of use. The staff of this station estimates an annual loss of 6 tons of organic matter per hectare due to oxidation. About one-half of this is compensated for by crop residues returned.

The director of this station reported that experiments on collective farms in the Minsk area show that a row crop is preferable as a first crop on reclaimed peat and muck. The tillage associated with row-crop production tends to make the soil more workable for succeeding crops and the row crop returns more income than a grain crop.

At the All-Union Scientific Research Institute of Agro-Forest Amelioration at Stalingrad, rotations are being used in some of the work on erosion control. Although this work is locally called research, it would be considered test-demonstration in the United States. For the light Chestnut soils (Brown soils of the United States) of the upper part of the slope above the Volga River terrace, this station uses a 7-year rotation with 4 years of perennial grasses, 2 years of grain, and 1 year of annual grass. Fields in this rotation are divided by contour planted shelterbelts at about 100-yard intervals. The lower slopes in this area are used for orchards and the gently sloping divides for grain crops. Where seen by the American study group, the perennial grass

areas of this rotation did not appear to be producing much forage.

The Akkavak Central Agro-Technical Station near Tashkent includes a special laboratory on crop rotations. The study group did not observe any of the work of this laboratory but we were told that the station has conducted a number of rotation experiments. For soils of the station, irrigated, medium- to fine-textured Sierozems, the station staff recommended a rotation of 2 years of alfalfa followed by 5 years of cotton.

At the Kazakh Scientific Research Institute on Grain-Crop Growing for the new-land area near Shortandy, rotation research is just getting underway and results are not yet available. The staff of this station is basing its recommendations for cropping systems on work done in other areas plus the experiences gained on the older farms in the region. Currently they recommend a five-field system, with four of the five fields in a 4-year rotation of fallow, wheat, wheat, and oats or barley. The fifth field is in an alfalfa-crested wheat grass mixture for 4 years. When the grass-legume mixture is broken up, this field goes into the grain rotation and one of the other fields is seeded to grass. Thus the system can be considered a 20-year rotation. Shifts into grass are on a flexible schedule to permit seeding in years of favorable moisture.

(Rotations for rice are discussed in the section dealing with rice production in the lower Kuban area near Krasnodar.)

Cropping Systems on Soviet Farms

On many of the farms visited by the study group, information on the cropping systems was obtained. Most of this information was given by the chairmen of collective farms and managers of state farms from prepared notes. Partly, the data given came from plans or recommendations rather than actual practice. Each farm was operating with a detailed land-use and cropping plan.

The Stalin Collective Farm on the terraces of the Vorskla River near Poltava is made up of a mixture of excessively drained, dunelike, sandy areas and black Humic Gley soils of sandy loam texture on the level areas. The excessively drained areas are used primarily for pine trees, although some of the better sandy soils have rye and vegetables, with lupines for green manure. Humic Gley soils are used in a rotation of corn, small grain, and sugarbeets with some 2-year grass-legume meadows. The exact rotation was not given.

On the Orzhonikidze Collective Farm near Dnepropetrovsk a 12-year rotation was reported to be followed. This rotation was used on gently sloping ordinary Chernozem of silt loam texture. The annual rainfall for the area is 350 mm. The rotation was as follows: (1) Fallow; (2) winter wheat; (3) corn for grain; (4) corn for silage; (5) winter wheat; (6) sunflowers; (7) fallow; (8 and 9) winter wheat; (10) corn, melons, or other row crop; (11) spring barley or oats; and (12) annual grass, especially Sudan. Some manure was being used on the crops in this rotation. The 5-year average yield of wheat was reported at 2.2 metric tons per hectare. The farm also had extensive orchards.

On the Koisug State Farm near Rostov two rotations were reported as being used. This farm was producing vegetables on irrigated medium-textured Western Azov Chernozem with the following 8-year rotation: (1 and 2) Perennial grass-legume mixture, (3) potatoes, and 4, 5, 6, 7, and 8) vegetable crops, such as cabbage, tomatoes, cucumbers, and eggplant in an irregular order. On nonirrigated areas with the same kind of soil, the following 10-year "fodder crop" rotation was used: (1) Barley with alfalfa, (2) alfalfa, (3) spring wheat, (4 and 5) winter wheat, (6) corn for grain or silage, (7 and 8) barley or oats, (9) fallow, and (10) corn.

The Lenin Collective Farm near Rostov, specializing in seed production, reported use of the following 10-year rotation on nonirrigated gently sloping Western Azov Chernozem: (1) Clean fallow or "occupied fallow;" (2 and 3) winter wheat; (4) spring wheat; (5) corn, or other row crops; (6) barley; (7) sunflowers; (8) perennial grasses; (9) perennial grasses; and (10) perennial grasses broken early. With this system the farm reported yields per hectare for 1957 as 2.1 metric tons for winter wheat, 1.9 tons for barley, and 1.3 tons for sunflowers.

The 40th Anniversary of the October Revolution Collective Farm on the bank of the Volga-Don Canal near Stalingrad reported the use of a 7-year rotation on irrigated medium-textured solonetzic light Chestnut (solonetzic Brown in U. S. system) soils. This rotation was as follows: (1) Sudan grass or millet, (2) tomatoes, (3) cabbage, (4) spring grain, (5) potatoes, (6) clean fallow, and (7) onions and carrots. This farm was moved to its present location 5 years ago because of the building of the Volga-Don Canal. The staff reported plans to introduce alfalfa into their rotation for irrigated soil in the near future in place of grass. On non-irrigated areas of similar soils, this farm reported use of the following 9-year rotation: (1 and 2) Crested wheat grass, (3 and 4) spring grain, (5) millet, (6) corn for silage, (7) spring grain, (8) barley, and (9) winter rye. Using this system the bookkeeper stated that 1.5 metric tons per hectare of spring wheat had been produced in 1958, a favorable year.

The Akhun Babaev Collective Farm on the Hungry Steppe about 85 kilometers southwest of Tashkent reported use of a 7-year rotation: 4 years of cotton followed by 3 years of alfalfa. The original soils on this farm were silt loam to silty clay loam, somewhat saline, Sierozems. All crops were irrigated. A yield of seed cotton of 3.55 metric tons per hectare was reported for 1957. This cotton was reportedly fertilized with 250 kilograms of ammonium sulphate, 350 kilograms of 20 percent superphosphate, and 6 to 10 tons of farmyard manure per hectare.

On the Savay State Farm in the Fergana Valley near Andizhan, a rotation of 6 years of cotton and 3 years of alfalfa was reported to be in use. The soils on this farm were medium-textured Siero-

zems underlain by coarse gravel at about 2 meters. All crops were irrigated, and the cotton received some manure and 126 kilograms of nitrogen and 117 kilograms of P_2O_5 per hectare in split applications. A few fields following alfalfa received potash also. About 150 kilograms of P_2O_5 per hectare are used on the alfalfa.

The 18th Anniversary of the Kazakh Republic Collective Farm in the Akmolinsk area reported the use of a 10-year rotation. This farm had been started in 1933 in the area now being developed in the new-land program. The soils are weakly carbonated Chernozems and Chestnut soils. The rotation is as follows: (1) Fallow; (2) and 3) spring wheat; (4) spring wheat seeded to grasses; (5 and 6) perennial grasses; (7) perennial grass plowed early; (8) wheat; (9) vegetables, or other row crops; and (10) annual fodder crops. No fertilizers or manure are being used. The 1957 wheat yield was 1.3 metric tons per hectare; this year (1958) they expect 1.7 or 1.8 tons.

The Shortandinski State Farm near Shortandy reported that continuous wheat had been grown to date on the newly broken land, but that future plans called for inclusion of fallow and perennial grasses in the rotation system. This farm has been in operation for only 3 years and has mostly medium-textured Chestnut soils.

Summary of Observations on Crop Rotations

Ideas about crop rotations and the crop rotations followed are dependent on factors unique to the Soviet economy and also reflect the views of the late Professor V. R. Williams. Little information on cropping systems of direct application to the more highly specialized farms of the United States was obtained by the study group.

The organic-matter content of the Sierozems has increased with irrigation. The study group saw few Podzols. But the organic-matter content in the cropped Chernozem and Chestnut soils seen is currently declining. This decline has probably not seriously affected production to date, but the increased crop yields reported for the Soviet Union since World War II are, if correct, due to factors other than the soil-building effects of crop-rotation systems.

BACTERIAL FERTILIZERS

"Bacterial fertilizers" used by the Soviets include (1) legume inoculants (Rhizobium), (2) azotogen or Azotobacter cultures aimed at inoculating the soil with nonsymbiotic in nitrogen-fixing bacteria, and (3) phosphobacterin consisting of the spore-forming bacteria, Megatherium viphosphatieum, which is used to encourage rapid decomposition of phosphorus-containing organic compounds (lecithin, nucleic acid) in soil organic matter. A fourth type, a silicate-decomposing bacteria intended to release soil potassium from alumino-silicate minerals into available form, also has been reported in the Soviet literature. We investigated use of only the latter three inasmuch as legume inoculants are of unquestioned value and are widely used in the United States.

Azotogen was used by many of the collective and state farms in nearly all parts of the country visited by the study group. Use of phosphobacterin appeared to be limited to peat soils, other soils high in organic matter, and to the new-land areas. Silicate-bacteria were not used on farms and, in fact, only the scientists appeared to have any knowledge that studies had been conducted.

Both azotogen and phosphobacterin are applied as seed treatments to a wide range of nonleguminous crops including corn, small grains, flax, cotton, and vegetables. Bacterial fertilizers are intended as supplements rather than as substitutes to chemical and organic fertilizers. Regular fertilizer programs are followed regardless of the seed treatment except on wheat in the new-land area near Akmolinsk where phosphobacterin was the sole treatment.

Farm managers and farm agronomists invariably indicated that bacterial fertilizers increased crop yields. This opinion was not shared by all scientists however. For example, at the Lenin Academy of Agricultural Science, Moscow, these statements were made: "Azotobacter not generally effective. Some cases, yes; some, no. The unfavorable situations are under study. Phosphobacterin is applied on soils high in organic phosphorus, mostly virgin and long-fallow lands rich in organic matter that is not active. There is no aim to replace mineral fertilizers with bacterial fertilizers."

A few outstanding soil experts questioned the value of the silicate-bacteria and others suggested that Azotobacter cultures were "usually ineffective."

We saw outdoor pot experiments at the experimental farm near Minsk where Azotobacter had been applied on oats. The statement was made that "bacterial fertilizers plus mineral fertilizers improve the straw-grain ratio" and that in the Minsk area "Azotobacter are of value only on peat soils." We could see little difference in oat growth between Azotobacter-treated pots and those without and commented accordingly. The reply was: "It is very difficult to judge except when the oats approach maturity." All pots showed large nitrogen response where nitrogen fertilizer was added.

At the Poltava Provincial Agricultural Experimental Station studies were reported underway testing Azotobacter and phosphobacterin on Chernozem-like Gray Forest soils. The statement was made that "We do not get much effect from phosphorus bacteria." However at the All-Union Scientific Research Institute on Corn at Dnepopetrovsk, it was indicated that bacterial fertilizers had been studied for many years on the Chernozem soils of the area and that phosphorus bacteria

were best while Azotobacter were effective only in wet years. It was stated also that phosphorus bacteria were used widely for corn on collective farms in the area.

At the Akkavak Central Agro-Technical Station on Sierozem soils near Tashkent in an irrigated cotton-producing area, the statement was made that Azotobacter had been tried on cotton but was not effective "unless alfalfa had been plowed down or a large amount of manure used." Also, it was stated that "collectives use Azotobacter" and "vegetable yields are increased by Azotobacter." On the large irrigated cotton growing Savay State Farm in the Fergana Valley, cotton seed was not treated with Azotobacter.

At the Kazakh Scientific Research Institute on Grain-Crop Growing near Shortandy for new lands near Akmolinsk where virgin Chernozem and Chestnut soils are being broken for wheat, we obtained the following information: "Phosphorus bacteria, tested on state and collective farms in the area, increased the yield of wheat from 0.15 to 0.20 ton per hectare. The best results are obtained during the first and second years after virgin lands are plowed and while the soil is still rich in organic matter. Farms in the area do not apply phosphate fertilizer hence it is not known whether phosphobacterin has any advantage on phosphated soil."

Samples of phosphobacterin were given us by the Ministry of Agriculture in Moscow. These are now under study at Beltsville. Azotobacter cultures were promised but so far have not reached us.

Our general conclusions are summarized as follows:

(1) Azotobacter and phosphobacterin are used on millions of acres in the USSR and very large sums are invested in their production, distribution, and application.

(2) Silicate-bacteria are not significantly used on farms regardless of earlier claims made in the literature as to their effectiveness.

(3) Although many claims of benefits were presented, we ourselves saw no concrete evidence that Azotobacter or phosphobacterin benefited crop yields.

(4) In our opinion, experimental methods and designs used by the Soviets in field evaluation of practices are too crude to permit drawing conclusions from the small differences, if any, likely to result from bacterial fertilizers.[1]

(5) Doubt apparently exists in the minds of some Soviet scientists as to the effectiveness of bacterial fertilizers. Other scientists may have hedged their statements to conform with the decisions reached by the Technical Board of the Ministry of Agriculture to produce and use bacterial fertilizers.

(6) Even though we saw no concrete evidence of the value of Azotobacter and phosphobacterin, carefully conducted tests in the United States should be made to prove or disprove their worth.

MINERAL FERTILIZERS AND MANURES

Mineral fertilizers appear to be playing an increasingly important role in Soviet farming. Except in the new-land area near Akmolinsk, practically all collective and state farms visited reported substantial use of fertilizers; and extensive soil fertility research and service programs were underway at most agricultural research institutes visited. Agricultural specialists frequently stated that fertilizer use was increasing or that shortages of fertilizers in certain areas would soon be overcome. The Ministry of Agriculture of the Ukrainian SSR indicated that their main problem in the next 7 years was not to expand the area of cultivated land but to increase the productivity of existing lands, which includes increased fertilizer use.

The All-Union Institute of Fertilizers and Agro-Chemistry

The organization of the All-Union Institute of Fertilizers and Agro-Chemistry, Moscow, which is a part of the Lenin Academy of Agricultural Sciences, gives some insight into the Soviet's overall research approach to soil fertility problems. This institute, staffed with approximately 200 professional personnel at its Moscow headquarters, divides its activities as follows:

(1) Laboratory dealing with soil fertility investigations specifically relating to podzolic soils.

(2) Laboratory for Chernozem soils (including the new lands).

(3) Laboratory for dry steppes and deserts.

(4) Laboratory dealing with methods of analysis (primarily quick methods).

(5) Laboratory on land tillage (including fertilizer application).

(6) Laboratory dealing with systems for fertilizer use in rotations.

(7) Mineral fertilizer laboratory, which evaluates kinds of fertilizers.

(8) Laboratory on physiological factors affecting plant nutrition.

(9) Laboratory of soil liming.

(10) Laboratory of organic fertilizers.

(11) Isotopic laboratory, which studies methods for using isotopes in plant nutrition.

(12) Microbiology laboratory, which studies role played by micro-organisms in plant nutrition.

(13) Economics department, which evaluates the economics of fertilizer use.

The fertilizer work of the Institute apparently is natonwide since it works cooperatively with 100

[1]Many data are cited in the literature in justification of the decisions to produce bacterial fertilizers. For example, in "Sovetska Agronomiya" 1953 (1): 95-96, it is stated that the decision of the Technical Board of the Ministry of Agriculture to produce phosphobacterin in the "greatest possible quantity" was based upon results from several hundred field experiments and collective farms. Data from 555 collective farms gave positive results in 60 percent of the cases.

other institutions and experiment stations throughout the Soviet Union and sends expeditions of scientists into various parts of the USSR. The Institute makes recommendations directly to the Ministry of Agriculture on fertilizer use.

Kinds of Fertilizer

Fertilizers used in the Soviet Union include ammonium sulphate, ammonium nitrate, anhydrous ammonia, ordinary superphosphate (18 to 20 percent P_2O_5), raw rock phosphate, and low grade potash salts (30 percent K_2O). Research investigations are underway on fused phosphates, defluorinated phosphates, metaphosphates, and urea but these apparently are not in general use. A statement was made that metaphosphates were good but that the industry did not produce them "for reasons of expediency." Apparently there is no factory-mixing of materials. Any mixing is done on the farms but for the most part fertilizers are applied as separate materials. All solid fertilizers we saw were of poor physical quality although some granulated superphosphates were reported to be in use. Fertilizer analyses are expressed as N, P_2O_5, and K_2O.

Rock phosphate apparently is used in two ways: (1) Composting with acid peats for at least 3 months then applying on the land, and (2) applying directly on leached Chernozems and other acid soils. It was stated at the Timiryazev Agricultural Academy, Moscow, that 200 million acres of land were suitable for rock phosphates and that 1 million tons of rock were applied annually.

Soil Fertility Maps

Maps showing available plant nutrient and pH levels are prepared by the institutes to guide fertilizer and lime-use on collective and state farms. For example, at the All-Union Institute of Fertilizer and Agro-Chemistry it was indicated that maps had been prepared for all farms in the Moscow region showing pH (determined in a salt solution) and available phosphorus (determined either by 0.2N HCl or water extraction). Soil samples are taken for each 20 acres of cropland and analyzed in district laboratories equipped for mass analyses. At Minsk, maps were prepared showing pH, available phosphorus, calcium, humus, and potassium. All maps are carefully hand colored. Apparently it is the intention to reanalyze the soils every few years although we were under the impression that this was not yet being done. The Ukrainian SSR, according to the Ukrainian Minister of Agriculture, is divided into 750 microregions each having its own soil-testing laboratory for recommending kinds and amounts of fertilizer.

Fertilizer Application Methods

The most widely used fertilizer application methods seemed to be broadcasting and disking in or drilling with ordinary grain drills. It was reported in the Ukraine that corn fertilizers were both localized in the hill and sidedressed, but there was little evidence of machinery for doing this on the farms we visited. Aerial application of solid fertilizers seems to be a fairly common practice. We saw a large number of airports, operated by a Special Service of Agricultural Aircraft, having an estimated 30 or 40 planes on the ground. Several farm managers reported that planes were used to apply a major portion of the fertilizer used on their farms.

Sidedressing of fertilizers is a common practice in the irrigated cotton-growing areas. One farm demonstrated a well-worn fertilizer attachment mounted on a tractor that sidedressed nitrogen on one side of the cotton row and a superphosphate-manure mixture on the other side.

Sidedressing fertilizer for cotton on irrigated Sierozem soil in the Fergana Valley.

We observed a large number of anhydrous ammonia applicators for injecting ammonia gas into soils at the Middle Asian Scientific Research Institute on Mechanization and Electrification of Irrigated Agriculture near Tashkent. These seemed to be copies of ours; in fact, a Schelm Bros. machine made in East Peoria, Ill., was alongside several Soviet machines. At the Uzbek Ministry of Agriculture it was stated that 20,000 tons of anhydrous ammonia were injected into the soils of the Uzbek Republic; hence the anhydrous injection method is used to some extent at least in the main cotton-growing area. Also exhibited at the Institute for Mechanization and Electrification was a crude version of the two-wheel, tractor-drawn broadcast-type spreader such as is widely used in the United States.

Use of Manures

Barnyard manure is used extensively in White Russia and in the Ukraine on sugarbeets, potatoes,

and vegetable crops and to some extent on corn and wheat. Rates of application usually range from 8 to 16 tons per acre. Most manure is broadcast although one farm manager stated that when in short supply the manure was applied in the hill for potatoes rather than broadcast. Some farms have compost piles. In the Minsk area these supposedly were acid peat mixed with rock phosphate. In the new-land area around Akmolinsk all manure is used as fuel and thus is not applied to the soil.

The Soviets have a theory that humic acids in manure favor the efficiency of the phosphorus utilization by plants. As a result, they frequently mix superphosphate with dry, pulverized manure in the ratio of about 2 parts manure to 1 part super on a volume basis. We saw a special machine developed for this purpose and also saw a demonstration of a sidedress application of the manure-phosphate mixture on cotton in the Tashkent area.

Fertilizer Practices for Individual Crops

It was exceedingly difficult to obtain a clear picture of the fertilizer practices actually being used on farms. Information often seemed contradictory. In many instances we felt that plans or goals were being quoted to us rather than current practices. According to the information supplied to us, fertilizer practices by individual crops appeared to be about as follows:

Irrigated Cotton.--The most complete and undoubtedly the most reliable fertilizer information supplied was for irrigated cotton in the Uzbek Republic.

Superphosphate is applied in three applications. From 50 to 70 percent is applied in the fall and plowed down, and the remaining 30 to 50 percent mixed with manure and sidedressed in two equal applications, the first when the buds start to form and the second at the time of mass budding and flowering. Nitrogen, usually as ammonium nitrate or ammonium sulphate, also is applied in split applications. About 25 percent is plowed down and the remainder applied as two or three equal sidedressings during the vegetative period. The first sidedressing is made soon after planting, and the second and third are applied concurrently with the phosphate-manure sidedressings. Total application rates ranged around 90 pounds of N and 90 pounds of P_2O_5 per acre although phosphate rates apparently are varied in accordance with soil tests. Potash generally is used but little because of the high potassium content of the Sierozem soils in the cotton-growing area. One farm manager reported using potassium on cotton after alfalfa and another reported light dressing in fields that showed deficiency symptoms. One farm reported foliar application wherein a superphosphate solution was sprayed on the leaves by plane.

The nitrogen program for cotton apparently was developed from studies underway at the Akkavak Central Agro-Technical Station near Tashkent. Based largely on outdoor pot studies, some of which we observed, conclusions were reached that nitrogen applied before bud formation expedites the process of ripening. It was reported that when nitrogen slows down ripening, "it is due to soil temperature reduction from shading by big plants and from humidity effects of the air." Too low amounts of nitrogen before bud formation extend the period before ripening and "early nitrogen applications encourage early flowering."

Tomato Transplants.--The following technique for applying starter solutions to tomato transplants was reported at a vegetable growing state farm near Rostov. A solution is made by dissolving 25 to 30 grams of ammonium nitrate in 10 liters of water and extracting 50 to 60 grams of ordinary superphosphate with 10 liters of water. About 600 liters per acre of the combined solution is injected by machine 5 to 6 cm. from the plants soon after they are set out. A second similar application is made 20 to 25 days later.

Tobacco.--Some insight on tobacco fertilization was obtained at the All-Union Institute of Tobacco and Makhorka. We did not visit any farms where tobacco was grown. On podzolic soils a mixture of inorganic and organic fertilizer is used to provide 40 pounds of N, 45 pounds of P_2O_5, and 45 to 50 pounds of K_2O per acre. Ammonium sulphate is the source of inorganic N and superphosphate of P_2O_5. The potash fertilizer used is a mixture of KCl and K_2SO_4 adjusted so that the chloride content does not exceed 40 pounds per acre. Nitrogen rates may be adjusted somewhat to control tobacco quality although quality is not of prime concern in most Soviet tobaccos. Most tobacco is grown in a rotation of 2 years alfalfa, 1 year grain, 1 year tobacco.

Corn.--Scientists at the All-Union Scientific Research Institute on Corn at Dnepropetrovsk stated that on Chernozem soils they recommend from 27 to 40 pounds of nitrogen per acre applied either at the time of planting or as a sidedressing. The nitrogen, however, "fails to improve yields during dry years." A hill application at planting of 5 pounds of P_2O_5 per acre from granulated superphosphate also is recommended. The Institute scientists indicated that in the Chernozem-soil-area manure usually was not applied on corn, and potash seldom is used because of lack of response.

We encountered several variations from the Corn Institute's recommendations. At a collective farm near Rostov, corn on Chernozem soil was reported as receiving 9 tons of manure, 40 pounds of N, and 27 pounds of P_2O_5 per acre applied by drill before planting. The Poltava Provincial Agricultural Experimental Station indicated that farms on Chernozem soils were applying 8 to 14 tons of manure and 350 to 450 pounds of mineral fertilizers per acre.

We frequently observed nitrogen deficiency symptoms on corn in the Ukraine. These symptoms were not severe but yields probably were adversely affected from lack of nitrogen, especially during the moist 1958 season.

On peat soils near Minsk, a collective farm reported drilling or disking in before planting 63 pounds of P_2O_5, 110 pounds of K_2O, and 2 pounds

of copper per acre. The statement was made that the peat soils were rich in nitrogen.

Wheat.--On the new lands around Akmolinsk no fertilizer is recommended or applied on wheat. We saw no evidence of nutrient deficiencies in the area.

Near Rostov on a Chernozem soil, one collective farm reported fertilizing wheat with 7 to 9 tons of manure, 35 to 45 pounds of N, and 20 pounds of P_2O_5 per acre. Another farm on Chernozem soil near Rostov used only phosphate and potash. Wheat fertilizers apparently are applied either by plane or with a grain drill.

Sugarbeets.--Indications were that all sugarbeets received fertilizer. At Minsk on peat soils, one farm was applying 63 pounds of P_2O_5, 110 pounds of K_2O, and 2 pounds of copper per acre drilled or disked in before planting. Near Rostov on Chernozem soils, a collective reported applying 18 tons of manure and 600 pounds of mineral fertilizer per acre consisting of ammonium nitrate, ordinary superphosphate, and low-grade potash.

General Conclusions on Fertilizers

Considerable research emphasis is being placed on fertilizers and manures in the Soviet Union. Poor experimental controls plus a tendency to accept somewhat blindly theories that are inadequately tested have led the Soviets to adopt certain practices that are highly questionable. These include the manure-superphosphate mixtures and the late sidedress applications of phosphate.

The Soviets offer excellent technical services to help guide collective and state farms in the effective use of fertilizers and lime. These include basic soil maps followed by soil testing and the preparation of special maps showing pH and available nutrient levels for individual farms.

The physical quality of mineral fertilizers in the USSR is poor by our standards. The use of unmixed goods results in high expenditures of time on farms in handling, mixing, and application.

Fertilizer-application methods generally are crude, and there seems to be a lack of precision fertilizer-application machinery. On the other hand, airplanes are used extensively for broadcasting solid fertilizers, and the anhydrous ammonia applicators appear to be comparable to ours.

Decisions supplant extension education in obtaining widespread adoption of fertilizer practices on farms. This insures rapid adoption of practices but magnifies errors of judgment and prolongs poor practices that otherwise would soon be discontinued.

We saw no fertilizer or manure management practices in the Soviet Union that were superior to ours. Many were definitely inferior.

TILLAGE AND MOISTURE CONSERVATION

Tillage practices currently being used in the Soviet Union reflect the influence of large-scale farming and the former system of machine-tractor stations. These machine-tractor stations are no longer operating as such, and the machinery has been taken over for use by collective and state farms. For this reason, the Soviets tend to have one set of large machines and tractors for preplanting tillage and another set of smaller machines and tractors for postplanting tillage. Use of the same tractor for plowing and for row-crop cultivation is not common. This has favored the development of large machinery for preplanting tillage. The prevalence of noxious weeds, especially field bindweed (Convolvulus arvensis), and the abundance of field labor are other factors influencing Soviet tillage practices.

Research on Tillage and Tillage Machinery

The Soviets are quite mechanically inclined and are directing a considerable effort to the development of new machines. The study group visited machinery-development research stations near Minsk and near Tashkent.

The Western Machine-Testing Station of the Ministry of Agriculture of the USSR near Minsk was specializing on machinery for organic soils. Several of their planters for use in organic soils were equipped with very heavy smooth rollers operating behind the seed-placement mechanism. We were told that these rollers served to compact the organic soil to establish capillary conduct between the surface soil and the water table, thus preventing the formation of a dry layer at the surface. This fostered better seed germination and minimized danger of blowing of the surface soil.

The Middle Asian Scientific Research Institute on Mechanization and Electrification of Irrigated Agriculture near Tashkent specializes primarily in machinery for cotton production under irrigation. The tillage machinery shown to the study group at this station was generally similar to American machinery. They had a special plow for plowing alfalfa ground that was essentially a five-bottom moldboard plow with a single solid blade extending the full width of the plow and mounted ahead of and at the same level as the plow points.

The study group saw only one field experiment on tillage. This was at the Akkavak Central Agro-Technical Station near Tashkent. The experiment was a comparison of plowing with moldboards to a depth of 28 to 30 centimeters, plowing without moldboards to a depth of 35 centimeters, and shallow disking as primary seedbed preparation for irrigated cotton on a fine-textured Sierozem soil. The staff of the station reported that in previous years the moldboard-plowed plots had yielded about 10 percent more than the plots plowed without moldboards or disked. Average cotton yields on the experiment had been about 5

metric tons of seed cotton per hectare. The plots were replicated 4 times and were provided with weirs for measuring the amount of irrigation water applied and the amount of tailwaters leaving the lower end of the plots.

Tillage and Snow Conservation in Dry Areas

At the Kazakh Scientific Research Institute on Gain-Crop Growing near Shortandy in Kazakhstan, tillage for moisture conservation is being studied. This is a fairly new institute and few research results on tillage are available. The staff recommends use of the moldboard plow in breaking native grassland and for seeded perennial grass fields. For primary tillage for grain following grain, they recommend plowing without moldboards 1 year and disking the next year.

One interesting practice used extensively in the new lands in Kazakhstan is snow ridging for moisture conservation. Special snow plows pulled with a large tractor are used. Another technique used to hold more snow on the fields in this area is to grow belts of sunflowers about 1 meter wide and 15 to 25 meters apart in grain fields.

Machine for ridging snow in fields. (Photo by Kazakh Scientific Research Institute on Grain-Crop Growing.)

The staff of the Institute reported that where no snow ridging is done, the winter accumulation of water in the soil amounts to 400 to 500 cubic meters per hectare. If snow ridging is practiced, 750 to 800 cubic meters of water per hectare will be added to the soil during the winter months. If strips of sunflowers are grown 1,200 cubic meters of water per hectare may be added to the soil during the winter months. When a growing season is dry, yields may be doubled if snow ridging had been practiced during the previous winter. Even when the growing season is moist, yield increases of 25 percent may result from snow ridging. Both of the farms visited in Kazakhstan reported that they practice snow ridging. One of these farms reported that they built ridges two or three times during the winter at a cost of 5 rubles per hectare for each ridging operation. The exhibits at the Ukrainian Agricultural and Industrial Exhibition at Kiev also contained illustrations of the snow-ridging process.

Sunflower strips, primarily for holding snow. (Photo by Kazakh Scientific Research Institute on Grain-Crop Growing.)

Tillage for Solonetz Soils

The Soviets have apparently devoted a considerable effort to special tillage operations for the reclamation of Solonetz soils. At the Stalingrad Agricultural Institute the staff reported development of a three-stage plow for inverting each of three layers or horizons of Solonetz soil without mixing the layers with each other. This plow was not seen by the study group. Later on, at a station for cotton mechanization near Tashkent, the study group was told that work to develop a 2-layer plow was underway.

Soil Compaction

At the All-Union Scientific Research Institute on Corn at Dnepropetrovsk, research on tillage seemed to be directed primarily toward increased labor efficiency. This Institute was promoting the formation of 2-man corn-production teams. One of these teams could handle 200 hectares of corn, doing all operations <u>except</u> preplanting tillage. We were told that they were interested in decreasing the amount of tillage in order to preserve soil structure. Here we received one of the few indications of concern with soil compaction or structure deterioration due to excess tillage. If soil compaction is a general problem in the Soviet Union it appears not to be generally recognized. Possibly the freezing and thawing associated with the severe winters tends to minimize the problem.

Mulch Tillage

The only machines for mulch tillage mentioned in discussion or seen on farms were the plows without moldboards and the duckfoot field cultivators. These machines did not appear to be designed to operate well with large amounts of surface residues. At the Poltava Provincial

Agricultural Experimental Station it was indicated that they had discontinued research with mulch tillage because of low yields. Very little crop residue is left on the soil in Soviet fields. Commonly the grain straw is removed and stacked following combine harvest of small grain. The study group saw a number of stubble fields being burned, but we were told that this is done only where pests are prevalent. Corn-harvesting machinery separates the ears and stalks and delivers the chopped stalks to a wagon. Sunflower stalks are harvested and burned, and the ashes are used as a potash fertilizer. Cotton stalks are removed from the field and used as fuel.

Tillage Systems for Corn

Observations of the study group would indicate that corn is most commonly grown on fall-plowed land in the USSR. Typical tillage systems for corn as reported by the All-Union Scientific Research Institute on Corn at Dnepropetrovsk and by collective farms on Chernozem soils in the Ukraine are as follows: Fall plowing (corn usually follows grain), from two to four spring cultivations with a field cultivator or disk, one harrowing with a peg-tooth or spring-tooth harrow, planting (in check rows 70 centimeters by 70 centimeters, with two stalks per hill), 1 postplanting harrowing, and four cultivations, two in each direction. The study group did not see any contour planting of row crops.

Tillage for Wheat

Early plowing of small grain stubble for the following wheat crop is apparently the rule throughout the Soviet Union. In several instances plowing and straw-stacking operations were underway in the same field. Plowing appeared to be generally about 6 inches deep with all trash buried. Several diskings or field cultivations following plowing were used for fall wheat, and the wheat was drilled in 7- to 10-inch rows. For spring wheat in Kazakhstan, the soil was fall plowed and cultivated or disked twice in the spring before drilling wheat.

Tillage for Cotton

All cotton production is on irrigated land. For cotton following cotton, the land is fall plowed following removal of the cotton stalks. If the land is leached for salt removal during the winter plowing, plowing is repeated in the spring. Cotton is planted in check rows 50 centimeters by 50 centimeters with planters having depth-control shoes. Cultivation is done by row-crop tractors. In several instances people were seen hoeing in the cottonfields. The amount of hoeing done was not discussed.

Summary of Observations

Soviet farmers use more tillage operations involving more man-hours and more tractor-power-hours to produce their crops than do American farmers. No tillage practices that are unknown in the United States were encountered. In all likelihood, increased efficiency of tillage in the USSR will have to await the general availability of herbicides for weed control. Use of mulch-tillage practices will probably not become common so long as the crop residues are needed for fuel and animal feed.

The practice of snow ridging is of interest but may not be useful in the American Great Plains where much of the snow comes during blizzards. The practice of using sunflower strips to catch snow is probably no more efficient than the stripcropping used in America.

DRAINAGE RESEARCH AND PRACTICE

The most critical drainage problems observed by the study group were in the humid northwestern part of the Soviet Union (Belorussia) and in the arid steppe and valley lands of Middle Asia now being developed for irrigation.

The two most active centers for research on drainage that were visited are: (1) The Belorussian Scientific Research Institute of Amelioration and Water Utilization at Minsk and (2) the Middle Asia State Project Institute for Water Economy and Cotton at Tashkent.

Director S. G. Skoropanov of the Institute at Minsk explained that the present Institute was founded in 1930 at the site of a previous one for swamp reclamation established in 1911. He gave three main functions for the Institute: (1) Research on marsh soils, (2) drainage and engineering investigations, and (3) development of theoretical methods for soil and water management. The Institute has 13 functional sections and laboratories, experimental farms, and an experimental development station for drainage machines. There is a staff of 150 engineers, agronomists, and soil scientists.

Plans are being developed to drain and reclaim 1-1/2 million hectares (3,700,000 acres) of excellent peat soils north of Minsk. This work will be done by the government and the land will be allotted mostly to state farms. On state and collective farms with marshlands and waterlogged soils, the engineering design of the drainage systems is done by the government. The government also builds all trunk and main outlet drains. Drains on the collective farms and tile systems are financed 50 percent by the government and 50 percent by the collective farms. The average cost of reclaiming marshlands is about 4,400 to 5,000 rubles per hectare. The cost runs even higher if extensive clearing of brush and land leveling are required.

The hydrotechnical phases of the research on drainage at this Institute, and application of the

results to drainage problems, under the direction of Dr. A. Ivitski, were perhaps the best and most fundamental of any farm-engineering practices seen by the study group in the USSR. Dr. Ivitski is carrying on research on:

(1) Development of methods for survey of drainage problems;

(2) Development of methods for calculating drainage discharge;

(3) Development of methods for calculating title-drain spacing;

(4) Studies on drawdown curves in various soil types;

(5) Evaporation and transpiration; and

(6) Coefficients of permeability of soils to be drained.

Time did not permit us to go into detail on all phases of this work but Dr. Ivitski has published some of the research results that can be made available through translation. Some of the highlights may be summarized as follows:

(1) The goal of drainage design is to "dewater" the soil as early in the spring as possible. The peak flow occurs when 130 degree-days Centigrade have elapsed after the temperature reaches 0° centigrade in the spring.

(2) The norm for optimum drawdown of the water level in peat soils is found to be 60 centimeters below the ground surface. To drain deeper causes more subsidence. They also strive for a nonfluctuating water table to increase yields.

(3) They indicated that they were using radioactive sulfur and chlorine in tracing water movements. Although we saw some of the equipment we did not see any experiments.

(4) They have developed a tile-spacing formula, included in their published materials, that contains 4 or 5 variables and would seem to be difficult to manipulate.

Later we saw some of the field experiments where experimental tile drains had been installed at 30-, 60-, and 80-meter spacings. The tile effluent was being measured and the water-table levels were checked by using large observation wells. These wells are said to be standard for the Soviet Union. They are made of iron pipe 10 centimeters in diameter and 2 meters long. The lower 1 meter is perforated, wound with spiral wire, and covered with brass screen. A disk 28 centimeters in diameter is welded to the bottom. A hole 28 centimeters in diameter is bored in the ground with a posthole auger. The well is installed and backfilled with gravel. This observation well seems more elaborate and labor consuming than we would use in the United States.

At the same Institute we visited the hydraulic laboratory. The equipment and facilities are generally adequate. One unique flume was used to test erosive velocity of flow in canals. The Soviets claim to have developed new formulae for computing the erosive forces of moving water. The flume is 15 meters long, 40 centimeters wide, and 75 centimeters high. The flume has glass sides and is mounted on two 1-meter-deep "I"- beams. The beams are hinged at one end, which is mounted on a concrete pedestal. The other end is movable vertically to allow a change in grade in the flume. The I-beams are apparently rigid enough to support the full weight of the water-filled flume with no deflection at midpoint. This idea may have application in our new hydraulic laboratories.

We spent nearly a full day at the Volma Lands Reclamation Project for a special field demonstration of equipment for drainage, land clearing, and reclamation. The director remarked that "6 to 12 million rubles have been spent on drainage and reclamation projects and experiments." We saw several machines as follows:

(1) A back-hoe ditcher digging an open drain 1 meter deep, obviously as a demonstration because we saw no stakes and the operator had dug about 500 linear feet downgrade. This machine was smaller than those commonly used in the Western States but might be comparable to those in the Eastern States.

(2) A wheel-type trencher and tile-laying machine digging a trench 40 centimeters wide and 140 centimeters deep. The rate or output was said to be 600 to 700 meters per 8-hour day. The grade was controlled by a wire strung at 50-meter intervals. A sag in the tile line every 50 meters might result. The machine looked comparable to some American ditchers but smaller. Subsequently one of the members of the study group saw a similar machine in the Netherlands which is manufactured by Barth, a Dutch firm. Possibly we saw a Barth machine with slight modifications. The tile line was being laid down a slight slope, and the people working in the trench laying the tile were calf deep in water. The tile were poor quality, soft, cracked, chipped clay.

(3) A pull ditcher used for making shallow surface drains in peatland. It was a huge, V-shaped, snowplow type of device pulled by two RD-8 tractors. One tractor went out 500 feet and dropped a rear bulldozer blade to act as a deadman. The other and the pull ditcher were fastened by cable and winch and pulled bodily through the peat soil. The ditch made by this device was 120 centimeters deep, 40 centimeters bottom width, 280 centimeters top width. The machine is

Demonstration near Minsk of a modern ditcher for tile in organic soil.

Demonstration in the Volma reclamation area near Minsk of a hydraulically controlled machine for making mole drains.

massive and cumbersome and could be used only on light peat soil cleared of trees and brush. They also had a smaller size machine that produced a surface drain of 60-80 centimeter depth.

(4) A Mole-drain device mounted on an RD-8 tractor. The mole itself is 25 centimeters in diameter and is attached to a hydraulically controlled knife arm. The device was alleged to maintain an even level on uphill grade away from the open drain on uneven terrain, but the principle of this device was not made clear.

(5) Ditch cleaner mounted on a Kom 80 tractor with a power takeoff to a 30-foot movable boom. At the end of the boom was a rotary armored disk wheel with paddles mounted on one face. The disk wheel revolves at a tremendous speed picking up water, mud, and weeds in the ditch and spewing them on the opposite bank and berm of the ditch. The forward speed is 800 meters per hour. It would be useful only in organic soils.

(6) Brush cutters, brush forks, and root rakes seen were massive and tractor-mounted. Although they worked well, they seemed inferior to the best American types.

(7) Virgin peatland plow that was a one-way moldboard plow cutting a furrow 75 centimeters deep. Coupled with this machine was a drag harrow and a roller.

These machines seemed to work well. They were obviously in some stage of testing and development. Most of them appeared to be adaptations of American or European types.

The study group visited the Middle Asia State Project Institute for Water Economy and Cotton at Tashkent in Uzbekistan for a half day. Other parts of days were spent in the field, especially on farms and field stations.

The Director of this Institute, F. N. Nadzhimóv, was with the Soviet Delegation to the International Congress of Irrigation and Drainage in San Francisco, May 1957. He has an excellent grasp of the fundamentals of both irrigation and drainage. The plans of the Institute are also reviewed by a section of the Academy of Sciences. Building trusts under the Ministry of Water Economy construct the works. All the design work, including dams, canals, drains, and irrigation schemes, is handled by this group. The staff of 500 are grouped into various sections and laboratories as follows:

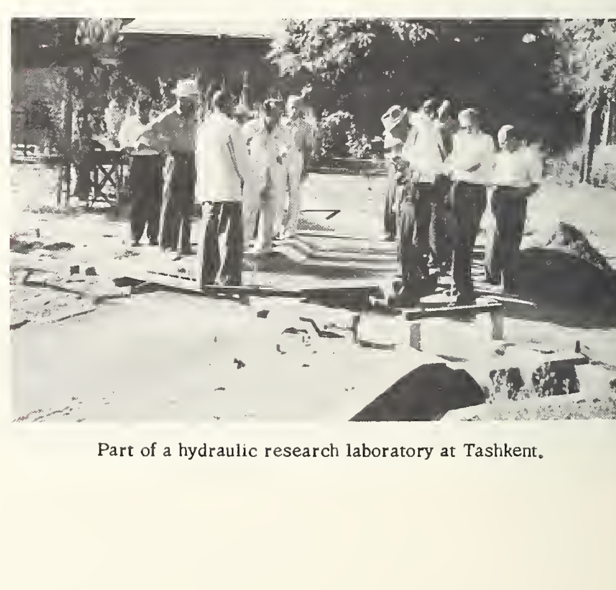
(1) Hydrotechnical laboratory (model testing);
(2) Drainage laboratory;
(3) Pump-development and testing laboratory;
(4) Building-materials testing laboratory;
(5) Soils laboratory (soil seepage, permeability, foundations); and
(6) Soil and water chemistry laboratory.

Their model-testing laboratory was interesting and important to the USSR since it is the only one they have working on irrigation structures. They were doing some interesting studies of silt bed-load that are similar to those done a few years ago by Ralph Parshall, USDA, retired. It would seem that some of the American hydraulic-testing laboratories are better equipped.

The biggest drainage project in this region is the reclamation and maintenance of irrigated agriculture in the Hungry (Golodniy) Steppe. The main crop to be grown is cotton. There are 1,288,000 hectares of cotton in the Uzbek Republic and the average yield in 1957 was 2.1 tons per hectare of seed cotton, which is roughly 1.4 bales of lint cotton per acre. But on the collective farm visited in the Hungry Steppe the yield was 3.55 tons of seed cotton per hectare, which is roughly 2.2 bales of lint cotton per acre.

The water supply is plentiful and the quality good (about one-half gram of dissolved solids per liter). The total project for drainage and irrigation includes 610,000 hectares. One-third of this has now been developed.

The original soils were mainly slightly saline Sierozems. The water table in this area stands at 1.5 to 2.0 meters with a "salt content" of 10 grams per liter. Capillary movement brings "salt" to the surface and root zone and this must be leached downward. Deep drains 2 to 2-1/2 meters in depth are dug 1,000 meters apart. The process of initial reclamation is to clear, level, and plow to 30 centimeters (12 inches). Then the land is diked off into 1/4-hectare plots and leached.



Part of a hydraulic research laboratory at Tashkent.

The amount of water used to leach is based on curves developed by Nadzhimov's staff. The more shallow the water table the less amount needed to leach. Mr. Nadzhimov said that the amount of water required to do a good leaching job varies from 3,000 to 25,000 cubic meters per hectare, or, we may say, from 10 inches to 75 inches of water is applied. The ultimate objective is to have 0.01 percent chloride ions in the soil.

The study group received a publication on these curves and norms of leaching. Some obscure points could be clarified by its translation. It seems probable, however, that with open drains 1,000 meters apart only a small amount of the salts are really flushed out and those from soils adjacent to the drains only. Elsewhere it would seem that the leaching is mainly pushing salts down below the root zone. The leaching process was estimated to be required every third year or oftener. According to Professor Victor Kovda's article presented at San Francisco in 1957 describing this method of reclamation in an irrigated area of the lower Amur Darya Valley, a comparable form of leaching is done every fall.

Whether the present drainage system being installed on the Hungry Steppe is adequate remains to be seen. On similar soils with comparable salinity it has been found that tile drainage is needed to insure a permanent irrigated agriculture.

Other drainage programs were observed in Rostov and at Krasnodar. The Rostov work under the supervision of A. F. Litvintsev seemed technically good, although so far there has been little actual application of advanced techniques.

Soviet agriculturists are aware of their tremendous drainage problems, perhaps more so in the humid areas than in the irrigated areas. Perhaps they will recognize more serious drainage problems in the irrigated areas as time goes on. Technically they are carrying forward a fair to good program of research in the humid areas. The program of research dealing with salinity and alkali reclamation and drainage seems to be less advanced, in certain respects at least, than those of the U. S. Salinity Laboratory. In the application of techniques to projects, farms, and field problems, the USSR is at the moment less advanced than the United States. In the humid areas they are clearing land and putting in surface and trunk drains, but few tile drains, as compared to the American Middle West and Western Europe. But this may develop in a few years. In the irrigated areas they have installed some deep open drains and some trunk drainage systems. Here too they have little tile drainage installed, as compared with areas in the United States such as the Imperial Valley, the San Joaquin Valley, the Columbia Basin, Utah, or Colorado where several million acres have been tile drained and an estimated 50,000 to 60,000 acres are tiled every year. On the basis of our hurried visit one might estimate that there are many less tile-laying machines in the Soviet Union than in the United States.

IRRIGATION FARMING

The Soviet Union has about the same area of irrigated land as the United States. According to the figures available to us, the irrigated cultivated land totals 11.07 million hectares, distributed as follows, in millions of hectares:

Middle Asian Republics	5.18
Transcaucasian Republics	2.11
Kazakh Republic	2.05
Russian Republic	1.48
Ukrainian and Moldavian Republics	0.25

In addition, it is said that 1.2 million hectares of soil are flood irrigated, probably mainly for pastures. These figures are from a bulletin of the Department of Water Economy, USSR Ministry of Agriculture, Short Description of Irrigation and Hydroelectric Projects in USSR. They are in general agreement with those given to us in several of the Republics. Over 4.2 million hectares have been placed under irrigation since the Revolution.

Irrigation takes up nearly all of the cultivated land in the Turkmen, Kirghiz, Azerbaijan, and Uzbek Republics. Irrigation is used mainly for industrial crops. The most important crops on irrigated soils are cotton, sugarbeets, tobacco, kenaf, hemp, alfalfa, vegetable, orchards, vineyards, rice, and some corn.

Irrigation Development

The government assists collective farms in expanding irrigation agriculture and, of course, pays all development costs on state farms. The Secretary of the Lenin Academy of Science told us the government makes all investigations and surveys for new irrigation and drainage projects without charge. Some collective farms pay half the cost of drainage installations on the farm, and the government pays half, depending on their income and local arrangements, which vary in different parts of the country. The main drains leading from farms are constructed at government expense.

In reclaiming new lands, such as the Hungry (Golodniy) Steppe, the government pays all the costs. If land on a collective farm is leveled, the farm pays all of the costs except where land leveling is connected with stump and stone removal. In such cases, half the cost is borne by the government.

Irrigation projects are handled by the government and all costs to deliver water to the farms are paid by the government.

Canals

Large distributing canals are constructed by the government. Collective farms pay for construction of distribution systems on the farm. Some canals, such as the Volga-Don, are multipurpose and irrigation is secondary. In the drier republics, canals are almost exclusively for irrigation.

Silt deposition is a general problem in irrigation canals. Schemes for silt control were observed at the Agricultural Exhibition in Moscow and at the Middle Asia State Project Institute for Water Economy and Cotton in Tashkent.

At Tashkent, models are made of the principal water and silt-control structures. Here we saw four models being studied for removing silt from water. Three of these models used the principle of baffle boards that divert the fine sand and heavy silt moving along the bottom of river channels through sluice gates while the upper strata of water, which are lower in silt content, are directed into the canals. Another model provided for settling basins with silt pumps to remove the silt settling at the entrance of the canals.

We observed two large canals in some detail: The Volga-Don Canal near Stalingrad and the Fergana Canal in the Fergana Valley near Andizhan.

The Volga-Don Canal is multipurpose--for transportation, electric-power generation, and irrigation. We visited the Volga entrance of the canal near Stalingrad, and drove in cars along the canal for about 60 kilometers in a southwest direction to the 40th Anniversary of October Collective Farm. Parts of several farms along the way were irrigated by pumping water from the canal or the river which feeds it.

The great Fergana Canal has a total length of 350 kilometers. It was constructed in 1939 by cooperative efforts of 180,000 people of the area in a period of 45 days. The canal consists of two sections: The Naryn and the Kara-Darya. The canal takes off from the Naryn River above the town of Uch-Korgon and flows into the Kara-Darya River, 44 kilometers away, supplying irrigation water to districts along the way. The Kara-Darya section begins near the village of Kuygan-Yar and continues for 306 kilometers. The intake capacity of the canal is now 175 cubic meters per second. This has been recently enlarged from the initial capacity of about 100 cubic meters per second. About 55 percent of the water diverted is delivered to farms. The remaining 45 percent is lost by seepage. The Soviets seemed undisturbed by the seepage losses from the canal systems and stated that the 45-percent loss from the Fergana Canal is about average.

There is at present no storage reservoir above the canal, but one is planned 90 kilometers up river, with a capacity of 1 cubic kilometer. The canals are cleaned twice each year.

The Fergana Canal supplies irrigation water for about 400,000 hectares. Each year the farms served by the canal indicate their cropping plans and water needs. The water master examines these in relation to the total supply and notifies each farm as to the quantity of water it can have.

We also made some observations of the irrigation system for rice from the Kuban Canal about 70 kilometers southwest of Krasnador. This canal is diverted from the Kuban River. It has a capacity at the intake of 51 cubic meters per second, but when observed on August 3 the actual intake was 21 cubic meters per second. The entrance to the main canal gates was wide, serving as a silt basin. When silt in this section reaches a depth of 80 centimeters a special sludge pump throws the silt out into wide basins constructed by the sides of the canal. Here the silt spreads out and is deposited.

Land Reclamation and Leveling for Irrigation

A land-leveling demonstration was put on for the study group on the Dneprovski State Farm on July 30. The farm was across the Dnepr River reservoir and consisted of about 18,000 hectares. At the time of our arrival, several crawler tractors and small carryalls were moving soil. No stakes were apparent in the field. Small holes were dug at 10-meter intervals to indicate the depth of cut. Conversely, a small pile of soil was used to indicate the depth of fill. In the center of a group of about 10 carryalls making the initial cuts was a landplane similar to those used in this country. The carryalls were small and appeared to lack the controls for a good leveling operation.

An engineer was in the field with a transit, but seemed to be inactive. From the demonstration we did not gain the impression that the supervisors were experienced in this type of operation.

Saline-Alkali Soil Reclamation--Hungry (Golodniy) Steppe

This is a major irrigation-development project near Tashkent. The plan is to bring 610,000 hectares of saline-Sierozem under irrigation. To date 205,000 hectares have been reclaimed and irrigated. The area yet planned for reclamation was said to be as follows: Uzbek Republic, 280,000 hectares; Kazakh Republic, 100,000 hectares; and Tadzhik Republic, 25,000 hectares.

The main canals for the Hungry Steppe area are under construction. Construction of these canals within the Uzbek Republic will require moving 400 million cubic meters of earth. Also 2,000 kilometers of drains are to be constructed.

The procedure being followed in the development is first, canal construction; second, drainage construction; and third, land reclamation.

The general system is to make basins and flood the soil in the fall with 25 centimeters of water and to flood again in the early spring before planting. Since the water table is high and salt accumulates in the soil, the soil is flooded in the fall after the cotton stalks have been removed (for fuel). Some areas are leached every year, others less often.

We visited the Akhun Babaev Collective Farm in the Hungry Steppe on August 8. It is located about 85 kilometers southeast of Tashkent along the road to Samarkand. We saw cotton 1, 2, and 3 years after irrigation development. The cotton looked fair to good. The open drains were about

Cotton on newly reclaimed soil (saline Sierozem) in the Hungry Steppe near Tashkent. First-year crop is on the left; third-year crop on the right.

2-1/2 meters deep and 1 kilometer apart. Near the road the water table, about 100 yards from a drain, was about a meter deep. In our opinion, the farm was underdrained and salt problems may become acute unless additional drains are constructed. Cotton midway between the drains appeared to be somewhat inferior to that near the drains. We could not see how full leaching could be effective where water had to move such distances through loam to silty clay loam soils.

The soils are nearly level saline Sierozems and appeared to have a good production potential if drained and managed properly.

Emphasis was placed on the desirability of maintaining a high water table to reduce the amount of irrigation water needed for cotton production. The water table is presumably fed by seepage from canals and ditches, plus extra water applied in irrigation. Even though the water used is of good quality, there will undoubtedly be an accumulation of salt in the ground water. We spoke to some of the Soviet engineers about our concern over salt and water tables, and they said they were considering the need for further drainage in the area.

Fergana Valley

As we flew up the Fergana Valley from Tashkent to Andizhan on August 10, we noted large areas of saline soils interspersed with small lakes or ponds. This extended up the central part of the valley with irrigated crops on either side. Many of the cottonfields showed large bare areas; apparently these were either salty or waterlogged. This situation resembles many valleys in Western United States. Presumably the lower lying soil in the center of the valley has a high water table, and salt has accumulated in the ground water and moved to the soil surface.

It was explained that salts had accumulated in this Fergana Depression sometime ago. Now a reclamation program is being developed to reclaim this central valley wasteland. Collective farms assigned some of this nonproductive saline land are each given a yearly quota of land to reclaim. In this program 3,500 hectares of such land were reclaimed last year in the Andizhan Oblast. There is a total of 250,000 hectares remaining to be reclaimed. The general program for reclaiming the saline land of the Fergana Valley was outlined as follows: First, enlarging the Fergana Canal to increase the capacity from 100 cubic meters per second to 175 cubic meters per second; second, larger drainage canals for collecting water from the lateral drains, which are both open and tile drains, installed after the main drains; third, leveling of fields to be reclaimed; fourth, construction of field irrigation canals and ditches to deliver water to the fields; and fifth, field leaching and tillage operations.

The field-reclamation procedures following canal and drainage installations begins with plowing. Then the fields are divided into plots of about 0.25 hectare each with bunds 30 to 40 centimeters high around them. The plots are flooded with water at a rate of 1,000 to 1,500 cubic meters per hectare, thus making the water depth 10 to 15 centimeters. The land is thus flooded 2 to 5 times depending on the degree of salt in the soil. Flooding is done during the fall or spring or during warm weather in the winter months.

When soil analyses indicate that the chloride ions in soil are reduced below 0.01 percent, leaching is stopped and the soil is allowed to dry. At this time the ground water should not contain more than 10 grams of salt per liter. The land is then plowed deep and a suitable crop is planted. The principal crops planted after leaching are alfalfa, wheat, or rice. Rice is considered one of the most effective crops for reclamation because of the continuing leaching its culture gives. The area of rice grown is limited, however, because of the high water table the flooding produces. Solonchak soils requiring 25,000 cubic meters of water per hectare for leaching are allowed to grow rice if there is a good drainage system.

As part of the development program roads are laid out, homes are constructed, and trees are planted. One purpose of the trees was reported to be increased transpiration, thereby helping to lower the water table, sometimes called "biological drainage."

In a conference on land reclamation with staff members of the Middle Asia State Project Institute for Water Economy and Cotton in Tashkent on August 13, it was reported that by 1965 2 million additional hectares of land would be reclaimed in the USSR. Out of this, 700,000 hectares are to be in Uzbekistan; 80 percent of this area has salty soil.

Cropping on Saline Soils

If chloride in soil is reduced by leaching to 0.01 percent or less, any crop is allowed to be

planted. If chloride is higher in concentration, crops are chosen according to salt tolerance. Sunflowers are considered the most salt-tolerant crop for their conditions. Sunflowers can stand 0.07 percent of chloride in the first meter of soil. Other crops endure the following percentages of chloride in soil:

Mangel wurzels	0.6
Cotton	0.045
Grain sorghum	0.045
Oats	0.02 to 0.03
Barley	0.02 to 0.03
Alfalfa	0.01 or less
Broad beans	0.01 or less

They have experimented with irrigating cotton with drainage water containing 5 to 7 grams of salt per liter. Yields of 4.5 tons of seed cotton per hectare were obtained if properly leached soils were used. Fields irrigated with such water are leached every year or every other year with river water.

They use a general rule that 1 cubic meter of water will leach 3 to 15 kilograms of salt.

In most places they have some calcium sulfate in the soil. They measure sodium and calcium in the irrigation water. As a rule the waters contain small amounts of sodium; 2 to 10 grams of calcium to one of sodium is most common.

Irrigation Practices

Irrigation practices were observed on farms in the vicinities of Dnepropetrovsk, Rostov, Krasnodar, Stalingrad, Tashkent, and Andizhan. Generally, irrigation practices were well carried out. Consolidation of small collective farms into large collectives and the development of large state farms has permitted the reorganization of water-distribution systems to reduce the area of land devoted to canals and permanent ditches. All field ditches are filled in before machine operations. Consequently, the irrigated farms are generally laid out for efficient use of farm machinery. On the other hand, the labor used in conducting irrigation practices appears to be much higher than for United States farms.

Rice

Rice production was observed principally in the Krasnodar area. There we visited the Kuban Rice Station, and the Krasnoarneisk State Farm, and the Michurin Collective Farm, which devoted much land to rice culture. The general practices include:

(1) The fields are leveled and bunds erected with paddies of about 1.5 to 2.0 hectares. The fields of several paddies are arranged so that canals and drains alternate and each field has a supply canal on one side and a drain on the other. Ricefields are usually 20 to 40 hectares in size. The canals, drains, and field bunds (in contrast to paddy bunds within the fields) are permanent installations.

(2) Land is plowed about 20 to 25 centimeters deep. It is next leveled, plowed shallow, disked and rolled, and then planted with drills. When alfalfa precedes rice the alfalfa is plowed in October.

(3) Irrigation water is applied after seeding to wet the soil thoroughly and to keep it wet. When the rice grows enough for the rows to be conspicuous the water depth is increased to cover weeds completely. Rice comes through a water depth of 25 to 35 centimeters. Most weeds do not. When the rice starts to tiller the water level is reduced to about 5 centimeters. When tillering is over the depth of water is increased to 12 to 15 centimeters and this depth is maintained until the rice is in the soft-dough stage. The water is then drained away and the field dries out.

They have found that rice yields are inversely related to soluble iron in soil; 150 to 200 milligrams of ferrous iron per kilogram of dried soil is considered a safe level. Values as high as 5,000 milligrams have been found in soil that has produced rice several years consecutively.

Vegetable Crops

Vegetable production on irrigated land was observed on the Koisug State Farm near Rostov, on the 40th Anniversary of October Collective Farm near Stalingrad, and on farms in the Tashkent region.

Good quality vegetables are grown. Those observed included tomatoes, eggplant, onions, cabbage, cucumbers, carrots, table beets, and peppers. The soil-producing vegetables was nearly level. Near Rostov they irrigated in both directions from field ditches. The length of run of water was about 100 to 150 feet although they said they usually used 250 to 300 feet. Near Stalingrad the length of water runs for tomatoes was only about 50 feet. They reported these short runs were because of sloping land and because they have not yet completed the planning of the farm.

Near Rostov peppers were reported to be irrigated up to 10 times during the season. Head ditches were filled in and the rows were cultivated after each irrigation.

Melons irrigated near Tashkent were planted on each side of furrows spaced 6 to 8 feet apart. Both rows were irrigated with 1 furrow. The slope was probably nearly 2 percent and a small stream of water was used, apparently for 24 hours or more.

Fruit Crops

Irrigated fruit production was observed near Rostov, Stalingrad, and Tashkent.

In one orchard near Rostov apple trees had a grass and alfalfa cover crop. These crops were hoed out of a basin about 10 feet in diameter around the tree trunks. These basins were filled with water during irrigation. In another orchard, apples were spaced 9 meters apart, cherries 5 x 5 meters, and plums 6 x 9 meters. Apples were irrigated with six furrows between rows

with 100- to 150-meter runs. They reported they apply 1,200 to 1,300 cubic meters per hectare for each irrigation for apples. Two irrigations are made during the growing season and one is made in the fall to fill the soil. On one farm they have drains to try to keep the water table below 2 to 2.5 meters. In another area where the water table was about 1 to 1.5 meters, the apple trees had a poor color and were not bearing much, and the plum trees were largely defoliated.

Fruit trees are used on the better soils in the "greenbelt" around Stalingrad where irrigation water is available. The trees are planted on a contour grade of about 0.5 percent. Irrigation is in furrows and flooding is between rows. They appear to work the water around the trees with considerable hand labor.

Cotton

Cotton is grown intensively in the Tashkent area including the Hungry Steppe and in the Fergana Valley. All cotton is irrigated in this Middle Asia region.

Some studies on cotton irrigation were observed at the Akkavak Central Agro-Technical Station located about 20 kilometers east of Tashkent. Cotton was formerly planted in rows 70 centimeters apart but now rows of 50 and 60 centimeters apart are being used. By the narrower spacings they are able to irrigate in every second row. The yield of cotton is about the same whether they irrigate every row or every second row. They claimed, however, that the soil becomes much more compact if they irrigate between every row and this requires more cultivation. By compaction they seemed to mean surface crusting around the irrigation furrows.

In all instances the quantity of water applied per irrigation was reported as 800 to 1,000 cubic meters per hectare. This is the quantity actually entering the soil. The length of water application was reported to vary all the way from 12 to 48 hours. This seemed to have no close relationship with soil texture but did increase with the distance between furrows.

They reported seven to eight irrigations per season at the Akkavak Station, two before flowering and four or five between flowering and ripening of the bolls. The total water used per season was reported to be 7,000 cubic meters per hectare.

In the Fergana Valley the single application quantity of 800 to 1,000 cubic meters per hectare was again asserted. The length of run was 80 to 100 meters and the time per setting of water was given as 24 to 48 hours. The soil was a loam to silty clay loam. In this area cotton on "meadow" soils is irrigated down every second row and that on Sierozems down every row.

Water Requirements of Crops

In the Ministry of Agriculture in Moscow we were told of a formula for estimating the water-consumptive use requirements of crops. The

Use of infiltrometer at the Akkavak Central Agro-Technical Station to determine the rates of water intake in different soils and under different systems of irrigation.

formula appeared complicated and included a number of variables that could not be adequately defined.

Lysimeter experiments are underway at the Amelioration Institute in Minsk. These studies are more concerned, however, with effects of water table on crops than with measurements of water use. Water use is measured but no data were given us.

A number of tanks were set in ricefields attached to the Kuban Rice Station near Krasnodar. Half of the tanks had open bottoms and half closed bottoms. In these, data were being collected on water consumption by seepage and by evapotranspiration.

Generally in our travels through the Soviet Union the country showed more vegetation for given precipitation values than occurs in the United States. Two factors may account for this difference: (1) The USSR has a cooler climate and shorter growing season than much of the United States, and (2) a larger proportion of the rainfall often comes in the growing season. Then too, the 1958 season had somewhat more than normal rainfall. The quantities of water claimed to be used in irrigation in the Soviet Union are smaller than are generally used in the United States. In Middle Asia where the growing season is longest they claimed to use not more than 7,000 cubic meters of water per hectare. This represents 22 inches of water entering the soil each year. Often they reported applying less than half of this quantity per season. It is difficult to estimate how much water was delivered to each farm. On most farms, however, there were high water tables and the plants secured

significant amounts of water from the ground water.

A uniform application on all farms of about 3 inches of water per irrigation seemed incompatible with the irrigation practices observed. Some of the soils where the water was indicated to run 24 to 48 hours per setting had a loam or silt loam texture and would have an infiltration rate of at least one-fourth to one-half inch per hour and probably higher. We found that 800 to 1,000 cubic meters per hectare per irrigation was the amount specified in instructions from the Ministry of Agriculture. Possibly on this, as on other items, we were given the figures in the plan rather than figures based on actual field measurements.

Conclusions on Irrigation

In their reorganization of irrigation agriculture, the Soviet Union has created more efficient units for mechanized operations. The irrigated crops observed appeared to be nearly comparable in yield to those on similar farms in the United States. The labor used in irrigation seemed much higher than in the United States.

Research related to field-irrigation practice is considerably behind that in the United States. Salinity measurements, for example, lack the precision of those used in the United States. The Soviets' working knowledge of salt tolerance of plants seemed more limited than ours and based on narrower concepts. We saw no well-designed irrigation experiments nor experiments designed to measure the interactions among water application, fertilizers, and plant population. In general, the Soviets seemed to be farming much closer to the limits of their experimental knowledge than are irrigation farmers in the United States.

SOIL MANAGEMENT FOR RICE PRODUCTION

Rice is one of the principal crops grown in the delta of the Kuban River near Krasnodar. Formerly the lower Kuban Delta was subject to annual flooding, but crop production has been made possible by works of improvement on the river. Now a system of levees and two floodwater reservoirs control the floods and supply water for rice production. Already 33,000 hectares have been reclaimed for rice in this area, 24,000 hectares are now being reclaimed, and 65,000 additional hectares are planned for reclamation.

Soils of the Kuban Delta

Within the principal rice-growing area, the following kinds of soils are recognized:

(1) Alluvium includes soils of recent deposits lacking genetic soil profiles. They belong in the group of Alluvial soils according to the American soil-classification system.

(2) Marsh soils are soils of young wet deposits without genetic soil profiles other than accumulations of organic matter in the surface and gleying of the subsoils. Shallow peat may be present in local depressions. The soils are nearly neutral and probably correspond to the minimal Humic Gley soils of the United States.

(3) Meadow soils are wet soils on the higher terraces of the delta. They have thick, nearly black, A_1 horizons over a slowly permeable strongly gleyed subsoil. They were said to be high in ferrous iron. These soils probably correspond to the American Humic Gley soils of medial expression in clayey material.

(4) Chernozem-like soils are moderately wet soils having a nearly black A_1 horizon, ranging from 16 to 40 inches thick, over a gleyed slowly permeable subsoil. Where seen, the A_1 was black (10YR 2/1) clay with common fine brown (10YR 5/4 or 5/6) mottles, massive where seen in an alfalfa field following rice. This overlays a kind of B_g horizon, from 16 to 32 inches thick, of very dark gray (10YR 3/1) clay with common fine brown (7.5YR 5/6) mottles. In one spot seen in a ditch, the soil was cracked into prisms some 12 to 18 inches across, but the prisms were massive, and in the field the soil appeared to be very slowly permeable. Beneath this was a highly mottled clay having lime concretions, 1/4 to 3/8 inch in diameter, as seen in excavated clods. The local soil scientist reported that ground water rose beneath the B_g horizon with irrigation of adjoining fields but was held there under hydrostatic head unless the B_g were broken. During the dry season and prior to irrigation, the ground water fell to 6 to 10 feet. This soil is also a kind of Humic Gley.

These kinds of soils are listed in the order in which they are found when one goes from the sea inland. They are also listed in the order of increasing potential for rice. The Chernozem-like soils are considered most productive of rice and are the principal ones currently used for that crop. Expansion on the "meadow soils" is anticipated as the area is developed, with a smaller acreage on the "marshy" soils. Limited acreages of both "meadow" and "marshy" soils are in rice now.

Locally the "marshy" soils are very strongly acid, with pH values as low as 4.0 or 4.5; but under rice culture they are quickly neutralized by the base-rich silt in the irrigation water. There are also local areas of Solonchak within the delta, attributed to salt-bearing underground water. These areas are mainly near the sea. Rice culture was reported to remove the salt of such soils rapidly.

At the present time only those soils not well suited to dryland crops are used for rice; the normal Chernozem of the region is used for other crops, partly because it is so productive of other crops and partly because it is too permeable for rice culture.

Rice is often used in the Soviet Union, as in the United States, as a crop for reclamation of salty soils, with the soil used later for other crops after the salts are leached out by the heavy irrigation of rice culture. The variety Dubovski 129 is said by the Soviets to be especially salt tolerant and suited to use on salty areas.

Research Work on Rice

The study group spent 2 half-days at the Kuban Rice Station, under the Ministry of Agriculture of the Russian Republic. One half-day was spent in conference with the staff at their headquarters in Krasnodar and 1 half-day at their experimental farm in the Kuban Delta. This experimental station was founded in 1932, the year rice production in the area started.

The operations of the station include laboratory work and pot experiments at the headquarters in Krasnodar, field experiments at the experimental farm in the Kuban Delta, and "checking experiments" located on state and collective farms in the Kuban Delta and in other rice-growing areas, including the Don Basin, the lower valley of the Volga, and in the Terek Delta. They have abandoned a system of outlying research stations in favor of conducting research with mobile teams on collective and state farms in outlying rice-growing regions. The agronomists on these farms participate in the conduct of the experiments and the work serves for both research and demonstration.

The pot experiments viewed in the grounds outside the headquarters in Krasnodar were not randomized and it appeared that location effects could be serious. We saw one experiment on photoperiodism where artificial lighting installed over certain pots was evidently the only variable. At the experimental farm, most of the land was handled in fields of about 5 acres. These experimental fields would be considered field trials in the United States. The only small plots in evidence were for variety testing.

Part of outdoor-pot experiments on rice in Krasnodar.

Rice on experimental farm west of Krasnodar in Kuban Delta. Windbreaks at field margins prevent ripples in water that would disturb seeds shortly after planting.

One of the plant physiology laboratories was equipped with a new Warburg apparatus of modern design.

A book, Physiological Elements of Rice Irrigation, by P. S. Ergzin, has been published by the Rice Station, along with a number of bulletins. Some of the observations of the work of this station are as follows:

(1) Plant breeding.--One of the primary objectives of the plant-breeding program is to provide short-season varieties that will permit a northward extension of rice production and that will permit mechanical harvest before fall rains. The present acreage is planted about 60 percent to Dubovski 129 (102 days), 30 percent to BROS 213 (112 days), and 10 percent to Krasnodar 424 (120 days). The staff of the Station indicated that they have varieties suited to production at 48° north latitude. They have 11 new varieties under increase, 25 in postscreening testing, and 1,500 to 2,000 in screening. Both Indian and Japanese varieties are used in the breeding program.

(2) Nutritional studies.--The Soviets feel that nitrates are of no value as a source of nitrogen for rice and are designing their cultural practices to promote NH_4-formation and to minimize NO_3-formation. They feel that NO_3 nitrogen is more readily lost in denitrification than NH_4 nitrogen. Turning under alfalfa is believed to promote the formation of NH_4 over NO_3.

After 2 years of alfalfa, nitrogen is not applied at planting time the first year but 150 kilograms of ammonium sulphate are applied at the tillering stage. The second year this same amount is broadcast both at planting time and at the tillering stage. Without fertilizer they expect 5 tons per hectare the first year, 4 tons the second, and 3 tons the third.

They are not working on the micronutrients for rice and feel that they have no serious micronutrient problems. They are not working on the blue-green algae as a potential source of nitrogen fixation for rice soils.

The Soviets report that upland rice yields well but that the weed problem is severe. Because of weeds, the cost of production of upland rice is higher than for flooded rice.

No work is being done on combined rice and fish culture. Fish in rice areas near the sea attract a predatory heron that destroys a great deal of rice. They stated positively that when the heron is not present, ricefields with fish in them outyield rice without fish.

(3) Irrigation studies.--The Rice Station has worked out a recommended irrigation schedule as follows:

(a) Immediately after planting, irrigate twice, with shallow depth of application (5 cm.), to sprout rice and weeds. Drain the surface water off both between and after these two irrigations.

(b) When the rows of sprouted rice become visible, flood to depths of 30 centimeters (12 inches).

(c) At the tillering stage, lower the water level to about 5 to 10 centimeters (2 to 4 inches).

(d) After tillering, raise the water level to between 10 and 15 centimeters and hold it at this level, with the water continuously flowing until the rice reaches the dough stage. At this stage drain the field and let the rice ripen for combining out of the windrow. Normally, 18,000 cubic meters of water per hectare (about 71 inches) are used for rice production.

The station staff has studied the amounts of water used by evaporation, transpiration, and deep seepage by the use of lysimeters with and without bottoms imbedded in rice paddies, with the top of the lysimeter extending above the water level in the paddy.

The station has studied size of paddy and recommends a large-field size of 230 meters by 1 to 1.5 kilometers, subdivided into paddy plots of 1.5 to 2.0 hectares, as the best compromise between leveling costs and efficient machinery use. The bunds around these fields are permanent. Normally not more than 300 cubic meters of soil per hectare are moved in leveling to get these layouts. All leveling is done with machinery to a precision of 5 centimeters.

Tailwaters flowing out of one paddy are reused in lower paddies.

(4) Rotations, fertilizers, and cultural practices.--The Rice Station reported two methods of culture, (1) rice in rotation with fallow, and (2) rice in rotation with alfalfa. The rotation with fallow is used mainly to control weeds but results in losses of organic matter. During the fallow year, the soil is plowed. This is followed by a disking and by peg-tooth harrowing in the spring. When weeds germinate again, the soil is plowed or, if not very weedy, cultivated. In September, it is plowed deeply and then harrowed the following spring in preparation for planting. All these operations are on dry soil, but they are experimenting with tillage operations while the soil is flooded to control a serious pest that resembles nutgrass. After fallowing, no fertilizer is used at planting but 150 kilograms of superphosphate and 150 kilograms of ammonium sulfate per hectare are applied at the tillering stage. No additional fertilizer is applied because it causes unfilled glumes. On poor soils, however, nitrogen, phosphorus, and potassium are applied at planting.

An excellent field of first-year rice after fallow was seen. The prediction was 5 metric tons per hectare (about 75 bu. of milled rice per acre). It was difficult to estimate yield at this stage, for only the central stems were heading, but in comparison with Philippine rice it was judged to be fully a 75-bushel-per-acre crop. Stand, tillering, and color were good.

The favored rotation when weeds are not too serious is 2 years of alfalfa followed by 2, 3, or 4 years of rice. Alfalfa is planted in March and gives one cutting and sometimes two, the year of seeding. The second year it is cut 2, 3, or 4 times and the aggregate yield expected for the 2 years is 10 to 14 metric tons of hay per hectare. In the alfalfa plot examined, the water table was at 15 to 18 inches in a pit, but the slowly permeable subsoil generally prevents waterlogging from below. Water tables are commonly at about 4 feet.

The alfalfa sod is plowed in October or later during the second year. The next year the following operations are performed: (1) Harrow in the spring as early as possible or plow and harrow if the field is very weedy; (2) plow to about 5 inches in early May; (3) level with a grader when dry enough; (4) disk; (5) roll; (6) seed with a drill at depths of 1-1/2 to 2 centimeters and at a rate of 180 kilograms per hectare; and (7) fertilize at tillering with 150 kilograms of superphosphate and 150 kilograms of ammonium sulfate per hectare. (The high rate of seeding was reported due to a desire to depend mainly on the main stem and not on tillers.)

For the second year of rice, the following operations are carried out: (1) Fall plow to 8 or 10 inches; (2) spring harrow; (3) plow deeply without moldboards in April; (4) land level; (5) broadcast 150 kilograms of superphosphate and 150 kilograms of ammonium sulfate per hectare at planting; (6) plow to 3-1/2 or 4 inches; (7) disk; (8) roll; (9) plant as for first year; and (10) broadcast 150 kilograms of superphosphate and 150 kilograms of ammonium sulfate at tillering.

The yield of first-year rice seen was estimated at 60 bushels per acre and that of the second-year rice at 50 bushels. Both were distinctly nitrogen deficient. Spots where fertilizer had been concentrated stood out in color and height. The estimates given were in 75-bushel-per-acre equivalents in both cases. It was reported that without fertilizer yields expected are 5, 4, and 3 tons per hectare for first, second, and third-year rice, respectively.

The station staff is cautious about using excess nitrogen because of a disease problem. They reported no serious problem of lodging before the grain is made, however. They seemed unaware of the low phosphorus requirement of the

rice plant and the greater need for phosphorus earlier than at the tillering stage.

Rice Production on Farms

The study group visited briefly the Krasnoarneisk State Farm and the Michurin Collective Farm where they were engaged in rice production. Only a short time was spent on each farm in discussions of rice production. On the state farm the manager himself did not appear to be completely familiar with all of the operations. Thus, information on rice production obtained from these farms has a lower degree of reliability than that obtained at the Kuban Rice Station.

The state farm had 4,200 hectares of rice out of a total of 10,300 hectares of cultivated land. Corn, fodder crops, orchards, and vineyards occupied the rest of the cropland. The average yield of rice was said to be 3 metric tons per hectare. The manager indicated fertilizer-application rates in excess of those recommended by the Rice Station but it is doubtful if this was correct. They showed us one field said to have been in rice for 5 consecutive years, then fallowed for 1 year, and in first-year rice after fallow at the time of our visit. The crop was good but perhaps not quite so good as that at the Rice Station and it appeared to contain several different varieties. The yield was estimated by the American study group at 35 to 40 bushels per acre.

The Michurin Collective Farm had 1,308 hectares of rice out of a total of 14,847 hectares. Grain, truck crops, and grapes were also being produced. A 7-year rotation was used on ricefields as follows: (1 and 2) Alfalfa, (3 and 4) rice, (5) fallow, and (6 and 7) rice. Rice was fertilized with 45 kilograms of P_2O_5 per hectare, 30 kilograms of N per hectare, and 50 kilograms of K_2O per hectare. This was applied in two applications, one-half prior to planting and one-half at the tillering stage. Fertilizers applied at tillering were said to be applied by plane. The individual rice paddies on this farm were smaller than the size recommended by the Rice Station. The rice crops seen in the field were not quite so good, perhaps, as those on the Rice Station.

SOIL EROSION AND SOIL BLOWING

Soil erosion is recognized as a problem by some Soviet scientists and agriculturists but has probably not received the attention it deserves. A section on soil erosion in the Dokuchaiev Institute employs 15 persons. This section has been concerned with standards and methods for mapping the distribution and kinds of soil erosion in the Soviet Union and, to a lesser extent, with methods of soil erosion control. Special maps are being prepared by some Republics. The Ukrainian exhibition at Dnepropetrovsk includes an exhibit of soil-erosion-control practices emphasizing soil-conserving crops, concrete channels, and tree belts. The Ukraine has an experimental station devoted in part to soil-erosion control. There was also one at Stalingrad. Detailed soil maps of some state and collective farms show eroded conditions either as delineated map units or by special symbols. In spite of this, it must be concluded that soil erosion is a more serious problem than is currently recognized generally in the Soviet Union. As one person said, "There is plenty of land and we are too busy with other things to be concerned with erosion."

Throughout much of the great expanse of nearly level to undulating plain of the Ukraine, White Russia, and in the new lands east of the Urals there appears to be little accelerated erosion. This includes a high proportion of the most productive soils for agricultural crops. Where the great rivers, such as the Dnepr, the Don, and the Volga have cut their channels into the great loess-covered plain, there is conspicuous and highly destructive erosion along the main rivers and their tributaries. The small intermittent drainways, which are graded to the main rivers or their tributaries 100 feet or more below the level of the plain, are extending gullies headward in a dendritic pattern. This becomes more conspicuous from west to east across the plains of the Ukraine, reaching major proportions especially along the Don and its tributaries and along the Volga. In Poltava Oblast, it was estimated that 120,000 hectares representing about 3.5 percent of the farm area is susceptible to serious erosion. The problem was clearly visible to the study group in this oblast but was much more prominent eastward in the vicinity of Kharkov, Dnepropetrovsk, Rostov, and along the Volga. The seriousness of the problem is directly proportional to the degree of dissection of this nearly level farmland by the main rivers and their tributaries. Because much of the plain between the dissecting streams is nearly level, sheet erosion in this region is not conspicuous and gullying appears to be the major problem except on the dissection forms themselves.

In more rolling landscapes along the upper reaches of the Volga and the Ural mountains east of Kazan, sheet erosion as well as gullying was conspicuous from the air. Considerable gullying was also noted locally in the new lands where incised streams were eating headward, though the acreage involved is probably small in proportion to the total land area. Sheet erosion was conspicuous in one rolling area near Alma-Ata, and the action of fast-moving rivers was evident from the air all along this mountain front. The very heavy silt load carried by the major rivers is evidence of the channel erosion that is occurring.

It was concluded that although the areas involved are probably not great in relation to the

great expanse of good agricultural land available, erosion by water is important to many areas and merits special attention.

If a fair sample of the research on erosion control was obtained at the stations visited at Poltava and at Stalingrad, the research program on this phase is probably the weakest of all phases of soil science.

Both at Stalingrad and at Poltava the major emphasis is on erosion control by vegetation. At Poltava slopes greater than 20 percent were recommended for reforestation. An experiment with stripcropping on slopes of 15 to 25 percent gradient was in progress, and one very poorly constructed terrace with essentially no channel was seen. Measurements of soil loss were crude and depended primarily on measurements of soil depth within wooden frames. There was essentially no work on mechanical structures. At the Stalingrad station, emphasis was on revegetating, filling gullies with sand pumped from the river terraces, and similar practices. Some low, flat terraces had been constructed but good mechanical structures to divert water from the headward-eating gullies were conspicuously absent although greatly needed.

Stripcropping on the side of a ravine at the Poltava Provincial Agricultural Experiment Station. There is a characteristic tree belt along the margin.

Aside from work at experimental stations, there was little evidence of a concerted effort to control erosion in the open country, and such evidence as existed was primarily in the form of vegetative practices such as tree planting, shelterbelts, or maintenance of steep slopes in permanent grasses. The study group saw little overgrazing of erosive soils under cover of grass or of protective forest plantings.

In summary, it was concluded that a much more intensive research program on erosion control, especially one that combines the use of mechanical structures with the vegetative practices and cultural operations, is needed. At least in certain areas a concerted effort to obtain erosion-control practices on affected areas is of major importance.

Soil blowing appears to be a major problem primarily on the very sandy soils of the first bottom lands and terraces of the major rivers. Large areas of shifting sands were seen along the Dnepr, the Don, and the Volga. These are receiving considerable attention, and in most places control measures through the use of vegetation appeared to be well advanced. Soil blowing on the finer-textured soils of the Ukraine and of the new lands east of the Urals does not, at present, appear to be an important problem. Conditions in the new lands, however, are such that soil blowing could become a problem after soil structure has deteriorated under cultivation and during the dry years that would seem inevitable in such a country. There was little evidence that the technical people working in the new lands are conscious of a serious danger. Special consideration is probably needed for education about the dangers of soil blowing on some soils in the drier areas of the new lands, especially to the east where the continental aspects of the climate are most pronounced.

SHELTERBELTS

Since we visited mostly areas that are naturally treeless, we saw many shelterbelts. Shelterbelt planting is given considerable emphasis in the technical schools and in the educational literature for farmers. The early work of Dokuchaiev in developing shelterbelts of oak is featured; and also the writing about them by Lysenko.

In the newer areas, it is clear that plans and projections for shelterbelts greatly exceed present performance. This may be a matter of "first things first" or that local residents, while not denying the official propaganda for shelterbelts, do not fully agree with their value in relation to cost. Nearly all farm managers insisted that windbreaks were "in the plan" if not on the ground. Still one sees a great many new shelterbelt plantings in most of the republics.

(1) In the areas visited, shelterbelts are mainly to protect soils and crops against summer rather than winter winds. Although we were informed that pine and other evergreen species were used, and doubtless there are some, the many shelterbelts seen were of deciduous trees, especially oak, acacia (locust), ash, maple, poplar, and elm. For reforestation on sandy soils, however, pine is used a great deal, sometimes with prior planting of willows to protect the young pine, and sometimes mixed with oak.

(2) The shelterbelts are also used as part of a scheme to control runoff as well as to reduce wind. Strips of trees are very commonly planted along the upper rims of ravines or gullies and at other topographic breaks. In gullies of fairly active erosion, trees and shrubs may be carried down the entire slope. In fact, most attempts

at gully control are confined to the planting and protection of permanent vegetation--grasses, shrubs, and trees. In many of these situations engineering structures, especially diversions and masonry chutes, will also be needed. As yet they are rarely used. (In several places such uncontrolled gullies, working back from deeply trenched streams, are seriously extending themselves.) On the whole much better engineering support is given vegetative erosion-control measures in the United States than in the Soviet Union.

(3) Sheep and cattle are herded in the Soviet Union. Thus one sees far less damage to shelterbelts and other forest plantings from the browsing and trampling of animals than in the United States. In fact we saw only one shelterbelt seriously injured by grazing animals.

(4) The older shelterbelts are quite wide. As in the United States, the early goal was to develop a wide strip with a true forest environment where regeneration could be expected. Now the emphasis is on narrower windbreaks rather than the wide shelterbelts.

Many well-grown belts planted since World War II on Chernozem in the Ukraine had 4 rows of trees and 2 outside shrub rows on all sides of the fields, except for gaps near the corners. Others are narrower still. Since many of the early shelterbelts (as well as forests) were destroyed by the Germans, one sees a great many gaps; and many windbreaks in areas occupied by the Germans are young.

Near Rostov on Azov Chernozem an old windbreak, some 40 to 50 feet high, had 9 rows of trees some 6 feet apart. The trees are mainly acacia but with ash and other deciduous species. Many new windbreaks here on land now being irrigated have 2 rows of poplars although we saw some with acacia, black poplar, ash, and elm. The windbreaks are some 10 to 15 feet wide. The trees are planted in the spring or in moist autumns. For nonirrigated land here, they suggest windbreaks 15 feet wide on all sides of fields 3,000 feet long and 90 feet wide.

(5) It was emphasized by the agriculturists at Krasnodar (and elsewhere) that windbreaks are essential for optimum crop yields on Chernozem and closely related soils. But in the great plain of these soils between Krasnodar and Rostov there were many gaps in a general pattern of windbreaks at about 1/4- to 1/3-mile intervals. Closer planting is recommended in the USSR.

The experts insist that some air should be allowed to pass along the ground through the belts and around the margins. Then too, with low branches or shrubs, too much snow piles into the belt itself, which robs the fields and delays tillage near the trees. For a large rectangular field they want a windbreak on all sides, with small gaps at the corners for passage of both air and machines. Then they have cross plantings at the proper spacing that stop some 15 to 20 feet short of the windbreaks along the field margins.

A 4-year-old shelterbelt on state fruit farm near Rostov. Trees are acacia, black poplar, ash, and elm.

At Krasnodar they recommend a rule that the spacing of windbreaks (of 2 to 4 rows of trees) be 25 times the height of the trees if the lower 2 feet is open for the passage of air; and 15 times the height of the trees if shrubs and low branches prevent the movement of air at the ground level.

In flying over the great plain of Chernozem soils between Krasnodar and Rostov, we saw that most windbreaks are spaced more widely than this; yet some do conform approximately to this rule where highly valuable fruit crops are grown.

(6) In the rice-growing area west of Krasnodar, single- or double-row windbreaks of poplar are common. A minority of our hosts considered their value for crop production doubtful in relation to their use of water, but most agriculturists considered them essential. We were told that the early spring winds make waves in the rice paddies unprotected by windbreaks. These disturb the seeds before they are rooted, which reduces the stand and the harvest.

(7) Although only a few small windbreaks are to be seen in the new-land area around Akmolinsk in northern Kazakhstan, unlike suggestions about windbreaks were given us by the administrators. Some favored tree belts; others only shrubs.

Experts of the Kazakh Scientific Research Institute on Grain-Crop Growing near Shortandy in this area favored windbreaks 300 meters apart consisting of 2 rows of trees, with the rows 3 meters apart. The best species seemed to be poplar, birch, and Siberian larch. Although no shrubs are planted in these windbreaks, they are recommending narrow shrub belts of yellow acacia (Caragana arborescens) at 40- to 50-meter intervals between the windbreaks. Both modern farming and research are so new in this area that no fixed system can be said to have been established.

In the new-land area they also use two-row strips of sunflowers some 75 feet apart, planted after the last cultivation of fallow, to hold snow. Many farms also ridge the snow with special tractor-drawn machines about two or three times during the winter. When wild hay is mowed, a few uncut strips are left.

(8) In the cotton-growing areas around Tashkent, rows of trees, especially poplar, line the roads and many of the large canals. One sees both old and new plantings of these and other trees near the villages, but few special windbreaks across the fields. Commonly in this area, however, silkworm production is combined with cotton growing, and rows of mulberry trees cross many cottonfields at intervals of 1,000 to 2,000 feet. These are pruned back to trunks some 6 to 8 feet high, with new growth in early August up to 15 or 20 feet.

(9) While driving across the Ukraine from Kiev to Dnepropetrovsk one is never out of sight of an old shelterbelt, a new windbreak, a natural forest grove on hilly or very sandy soil, or a plantation on hilly or sandy soil for protection against erosion. Yet the pattern varies widely. One sees many open spaces of several miles and other areas with some sort of windbreaks or other plantings every 2,000 to 3,000 feet.

(10) Special efforts are being made for windbreaks and other tree plantings near Stalingrad. Unhappily, we did not have time to visit the results of a great effort now going on in the Volga Region east of Stalingrad. At Stalingrad it is not easy to grow trees. The rainfall is only about 9 inches. Many of the Brown soils have solonetzic B horizons and there are spots of Solonetz.

At Stalingrad there is a special institute for tree growing called the All-Union Scientific Research Institute of Agro-Forest Amelioration. They are engaged in the study of varieties of fruits, including grapes, and forest trees that can be grown and of methods to use.

A huge "green belt" is being planned around the west of Stalingrad. Since the city stretches for many miles along the west side of the Volga, this means a broad semicircle of trees about 1 to 2 miles wide and more than 40 miles long. Ravines push back from the river. On the strongly sloping areas the soil is smoothed and terraced to conserve water for the trees at a cost of about 2,000 rubles per hectare and about 1,500 rubles for planting. (This would be very roughly $180 per acre, total.) The soils here are mainly rather sandy Brown soils with some solonetzic influence. These new plantings in the most hilly areas of terraced soil are single or double rows, near together, of fruit trees, nut-bearing trees, and others.

We examined some of the older belts planted roughly on the contour about 10 years ago. They have up to 10 rows of oak, ash, elm, and other unidentified species of trees along with currants and other shrubs.

The best areas here are smoothed and supplied with enough irrigation water for grapes, cherries, and especially apples. Some varieties of cherries do not require irrigation.

Much work remains to complete this scheme. On the great area east of the Volga, it is said that special efforts are being made for extensive shelterbelt planting on old farmland and on new land being brought into use.

(11) Shelterbelts are widely used for city and village protection, coupled with fruit growing and with areas for "culture and rest." Rostov, for example, has a so-called "green belt" around it. We noticed ash, acacia, maple, and others. Some parts of this wide area includes tree farms for timber.

SOIL CONSERVATION PLANS ON FARMS [1]

All farms visited had a longtime plan for soil use and improvement. On some it was a bit difficult to understand clearly when we were being given the plan and when present performance. Often these two were fairly wide apart. But there are several good reasons for this, among them the following:

(1) It took great effort to restore minimum housing and other facilities in the areas occupied by the Germans during World War II.

(2) Agriculture is changing rapidly as machines and chemicals become widely available.

(3) Emphasis is being given to large-scale works for drainage, irrigation, and hydroelectric power.

(4) Recently farms have been urged to increase their quotas of meat, butter, and milk.

(5) Very recently, the principal machines have been transferred, through purchase by the farms, from the machine and tractor stations to the farms.

(6) Some general improvements in farm prices have given farm people better prospects.

(7) In the new-land areas--including areas being brought newly into use or into more intensive use through drainage, irrigation, and flood control--minimum farm housing and land preparation for crops must come first.

Soil Maps

All farms visited had had a soil survey. Not all other farms have soil maps, but the work is going forward rapidly. Those made before World War II are fairly general. Recent ones, although less detailed than soil maps of comparable areas in the United States, looked fairly good, although we had little opportunity for field checking. It was emphasized that all new-land areas are carefully surveyed in advance of reclamation or settlement.

The system of soil classification used is that promulgated by Professor K. D. Glinka before

[1] This section deals only with the broad aspects. All other sections also bear directly on this subject.

the Revolution. The present scheme is much as he left it about 1930, except for minor changes, especially local modifying adjectives to show finer differences in local landform, geological material, and other features on detailed soil maps than he considered for his small-scale maps.

Interestingly, this basic scheme is such a prominent feature in all teaching of soil scientists and agronomists, in the institutes as well as in the universities, that it is very well understood throughout the country. Although modern soil maps in the United States are probably considerably more detailed and more accurate than those in the Soviet Union, the agricultural workers other than soil scientists in the United States are much less well trained in the principles and use of soil classification. Thus the soil maps in the Soviet Union are fairly easily interpreted by most farm managers or farm agronomists, and by those giving advice to farm people.

Commonly the soil mapping is followed by a soil-testing scheme, and other maps, additional to the basic soil map, are prepared for available phosphorus, available potassium, organic matter, soil acidity, and the like as relevant. These guide farm plans for using lime and fertilizers and for cropping systems.

Farm Plans

Each farm visited was said to have a farm-plan map. Several were seen. Some were separate from the soil map, some were drawn over a copy of it. On the whole, these were competently made for cropping systems and especially for land use.

Perhaps partly because of the nature of the controls in the Soviet system and partly because most agriculturists are trained in soil science, the land-use planning is impressive. One rarely sees important areas of soils unsuitable for crops used for crops. For example, very sandy soils with moderate or severe hazards of soil blowing are placed under permanent vegetation that is adequately protected. We were particularly impressed with the careful selection of soils in the new-land areas to avoid those with hazards of blowing or erosion or those with difficult solonetzic claypans. And in irrigated areas intelligent care seems to be taken to avoid soils that cannot be economically irrigated or kept free of harmful salts by good practices. (Yet in some areas the drainage ditches are much too far apart and more drains, preferably tile, will be needed to keep the soil productive.)

We got the impression that some of the rotation planning is theoretical rather than real. Many plans call for rather complicated 9-, 10-, and 12-year rotations that did not seem to be followed very closely. Part of the differences between plan and practice have already been explained. Then too, farm managers here, as elsewhere, want the most income from their land that they can get without injury to it.

As another example, the shortage of proper machines for applying fertilizers suggest that the fertilizer part of the plan may not be fully carried out on several farms. Here again, however, the Soviets themselves realize that fertilizer is in short supply, despite the big increase in its use, and new plants are under construction and others are planned. Since the efficient use of fertilizer requires considerable skill--and new skill to some collective-farm chairmen--one suspects that this too is a limiting factor on some farms.

Manure is very poorly handled on most farms. Although machines are available on many farms to help remove the manure from the dairy barns, it is hauled to the fields in horse-drawn wagons, dumped into piles, and spread around with a fork in the manner of European farmers from the 13th to the 20th century. In the treeless plains of the new-land area of Central Asia and elsewhere, the manure is pressed into large bricks for fuel, and some for building warm walls and ceilings for houses.

Engineering on Farms

Although considerable emphasis is given to mechanical engineering for using large machines, applied civil engineering on farms lags. The large schemes for irrigation, drainage, and the like, handled as government projects, appear to be competently planned and installed, but the simpler civil engineering practices for water control on the farms themselves are not well handled. In many places, for example, diversions and other small structures are needed. Many field drains are too far apart for best results. In places, irrigation water is unevenly applied and much of it wasted. Where good jobs of irrigating are done, a lot of hand labor is used on them.

Control in Farm Planning

In many ways both the Communist Party and the Government--through administrators of the raions (the lowest level of organization), oblasts, and ministries of the republics--control the selection of managers of farms and the farm plans.

Managers of state farms are appointed by the Government. Theoretically, the chairmen of collective farms are elected by the members; actually, however, effective suggestions are made through the Party, which has full-time agents on the farms. On the whole, we were impressed that most chairmen and managers were good agriculturists and good administrators. No doubt we saw farms that were well above average.

Skills of management--both agricultural and political--have been highly concentrated through consolidation of collective farms and enlargements of state farms by reclamation of new land, including drainage, irrigation, and flood control. Now there are only about 90,000 farms in the Soviet Union.

Farm planning is done cooperatively among responsible officers of the farm, scientists and engineers from the institutes, and staff specialists of the agricultural administrations. For example, at Rostov we were told that about two-thirds of the collective and state farms have soil surveys. Teams of specialists make the soil surveys, interpretations, and suggested plans. The chairman or manager and agronomist on the farm take full part. Besides these farm people some 300 specialists are involved. The plans are discussed at meetings with the specialists. After full discussion and settlement of the issues managers of state farms and chairmen of collective farms are required to follow these plans.

Yet everything considered, basic soil conservation planning is firmly established in the Soviet Union. Barring some drastic economic or other change, the signs point to rapid improvement and significantly improved yields. Labor efficiency can be expected to rise also. But this depends a great deal on alternative job opportunities for people on farms as well as upon education, research, and stable prices. Many farms have twice, or even three times, the labor that is really needed.

SOME APPROXIMATE CONVERSIONS

Yield per hectare		Yield per acre in American units						
		Potatoes[1]	Sugarbeets, fodder, etc.	Wheat[2]	Corn[2]	Oats[3]	Rice[4]	Lint cotton[5]
(Metric tons)	*American units*	*Bushels*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bales*
1 ton..........	892.55 lbs...	14.8		14.8	15.9	27.9	19.8	0.62
2 tons.........	1,785.10 lbs...	29.7		29.7	31.9	56.0	39.7	1.25
3 tons.........	2,677.56 lbs...	44.6		44.6	47.8	83.7	59.5	1.87
4 tons.........	3,570.20 lbs...	59.5		59.5	63.1	111.6	79.3	2.51
5 tons.........	4,462.75 lbs...	74.4	2.23	74.4	79.7	139.5	99.2	3.13
10 tons........	4.47 tons..	148.8	4.47					
20 tons........	8.93 tons..		8.93					
40 tons........	17.86 tons..		17.86					
50 tons........	22.32 tons..		22.32					

[1] 60 pounds.
[2] 56 pounds.
[3] 32 pounds.
[4] 45 pounds.
[5] 35% conversion.

CONVERSION TABLE

1 kilometer	=	0.62137 mile
1 meter	=	39.37 inches
1 centimeter	=	0.3937 inch
1 millimeter	=	0.03937 inch
1 inch	=	2.54 centimeters
1 liter	=	1.0567 quarts
A liter of water	=	2.2046 pounds
1 cubic meter	=	1.308 cubic yards
1 centner	=	220.46 pounds
1 metric ton	=	2,204.6 pounds
1 hectare	=	2.47 acres
1 acre	=	0.4047 hectare

U.S. GOVERNMENT PRINTING OFFICE : 1959 O - 508108